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Administrative Report

MARINE ENVIRONMENTAL QUALITY COMMITTEE

by

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1982

Belgium
(W. Vyncke)

1. The effects of dumping industrial wastes off the Belgian coast on the fish and shrimp stocks and invertebrates were studied further.

   A monitoring programme was carried out every three months at two dumping areas for industrial wastes derived from titanium dioxide production; one area for wastes from the production of thiocarbamates; an area for wastes from the production of proteolytic enzymes and an area for an industrial waste containing 1.5% phenol.

   A biological and physico-chemical survey was carried out.

2. The monitoring programmes on heavy metals and organochlorines in fish and shellfish were continued. Samples of cod, plaice, flounder, brown shrimps and mussels from the Southern North Sea were analyzed. The study on the evolution of mercury in Solea solea in the North Sea and the Irish Sea was continued.

3. The biological and physico-chemical monitoring of the Kwinte Bank, Buiten Ratel, Oostdyckbank and Gootebank where sand extractions are taking place was continued.

4. Petroleum hydrocarbons were analysed in sea water, sediments and biota samples from off the Belgian coast.

5. The radioactivity of sediments and in samples of fish and shellfish from Belgian coastal waters was measured.

6. A regular monthly survey carried out to assess the general state of the marine environment was initiated in 1981. Samples were taken in a 23 station grid. Automatic profiling of general oceanography parameters were included in the routine. The following parameters were measured:

   6.1 General oceanography.

   Temperature, salinity, plant pigments by fluorimetry, dissolved oxygen, suspended matter, turbidity (optical), light penetration (Quantameter, Secchi disc), pH, and meteorological observations.

6.2 Cycle of biogenous elements.

Dissolved nutrients (NO_3^-, NH_4^+, PO_4^{---}, SiO_2); plant pigment, by spectrophotometry; zooplankton biomass; and chemical composition.

6.3 Cycle of pollutants.

Heavy metals (Zn, Cd, Pb, Cu, Hg) and PCB, dissolved and in suspended matter.

7. Other surveys or specific campaigns, chiefly at sea:

7.1 Moorings of current meters and tide gauges at three stations.

7.2 The survey of the benthic fauna (now 36 stations) was continued. There is a link with other activities (COST 47) and programmes (influence of sand and gravel extraction, see item 3).

7.3 Every two months, ichthyoplankton were surveyed on a regular 20 station grid using an undulating high-speed sampler.

7.4 The study of the diffusion of ichthyoplankton (plaice eggs and larvae survey) was set forth in collaboration with the Fisheries Laboratory, Lowestoft. Measurements of zooplanktonic biomass and of plant pigments are part of this programme.

7.5 Three special cruises were organized to improve the knowledge of the distribution, speciation, and transformation rates of organic matter present in the marine environments (stocks of small organic substrates; uptake by bacteria; exoenzymatic processes; phytoplankton production; and excretion, grazing, etc.).

7.6 Air-Sea interface exchanges of metals were investigated during the above mentioned three special cruises.

7.7 Geomorphological surveys (bathymetry, sedimentology, seismology) of two areas in front of the Belgian coast were performed.

7.8 A new monitoring program for the pollutants discharged from channels and sewage outfalls was started in 1981. Samples were taken simultaneously from the points of input and offshore. Four campaigns were devoted to this exercise.

7.9 The area off Zeebrugge (14 stations) was monitored on four occasions for faecal bacteria, BOD and bacterial respiration, to elucidate marine biodegradation mechanisms.

7.10 Sediment cores were samples from 4 stations to study biodegradation of organic matter in the sediments.

7.11 Participation in the Manchex exercise (Bonn Agreement) in June.

8. Survey of Western Scheldt:

8.1 The monitoring programme on the Scheldt was continued. Regular monthly surveys were made at 36 stations to provide longitudinal profiles of physico-chemical parameters (salinity, temperature, dissolved oxygen, redox potential, pH, turbidity), to study sedimentation processes and heavy metal transport mechanisms, as well as nutrient interactions and bacterial activity.

8.2 Suspended matter sampled in the Western Scheldt was analyzed for possible radio-contamination. This programme covered three stations on three occasions.

8.3 Heavy metals transport processes and accumulation in the sediments have been studied (2 campaigns and 9 sampling stations). Localisation of sedimentation and erosion sites was made using a "sub bottom" sampler.

Canada
(J. Uthe)

1. Attempts were made in late July to investigate whether Gonyaulax blooms undergo diurnal vertical migration in the south-central Bay of Fundy. In August water samples were collected throughout the entire bay to determine the horizontal distribution but the July bloom dissipated so rapidly that few Gonyaulax were present in the plankton when these studies were conducted. (St. Andrew's)

A study conducted last winter and spring showed that Gonyaulax cysts were widely distributed in the Bay of Fundy, at offshore, inshore and intertidal locations. The cysts were found to be toxic, containing as much "paralytic shellfish poison" as the motile cells which has implications for the toxification of shellfish (and finfish?) during non-bloom seasons. Studies were conducted during the fall and winter to compare cyst distribution and abundance to last spring and to investigate the horizontal and vertical distribution of cysts in more detail (St. Andrew's).

Shellfish toxicity data since 1944 show a pattern of intensification of Gonyaulax blooms and shellfish toxicity in the past 8 or 10 years and a recent trend of shellfish toxicity extending into non-bloom periods (St. Andrew's).

2. The uptake and elimination of aqueous solubilized polycyclic aromatic hydrocarbon (5 different non-alkylated compounds) was studied in lobster (Homarus americanus). The bioconcentration factors of all PAH were high except for perylene (3000-84,000). No excretion was detected over a period of 13 days following transfer to clean water (St. Andrew's).

High uptake rates and low excretion rates were found in Mya exposed to PAH in seawater. Calculated bioconcentration factors ranged from 1,280 for phenanthrene to 10,000 for perylene. These factors were much lower for animals exposed to PAH bound to sediments (890 for phenanthrene, 3,900 for triphenylene) (St. Andrew's).

The concentrations of organochlorines in Trinity Bay, Nova Scotia, herring sampled in 1980 were determined. While the concentration of organochlorines in the muscle increases markedly from 2- to 3-year old fish (wet weight) so does the lipid content, resulting in a decrease in the organochlorine content when expressed on a lipid basis. From 1972-1980 concentrations of PCB, DDT and its metabolites have decreased exponentially with a half-life of about 3 years (St. Andrew's).

Lobsters reared in an aquaculture facility were analyzed for nonpolar organics in their hepatopancreas. Most specimens contained butylated hydroxytoluene (BHT, 2, 6-di-tert-butyl-4-methyl-phenol), polycyclic aromatic hydrocarbon, benzothiazole, polychlorinated biphenyl, p,p'-DDE, trans-nonachlor, hexachlorobenzene, and a dichlorobenzene. A BHT metabolite, 2,6-di-tert-butyl-4-methylene-2,5-cyclohexadienone was found in one sample while some samples contained pentyl benzoate, fatty acid esters and possibly aliphatic nitriles (St. Andrew's).

Zinc exposure (25 ppm) had no effect on the Adenylate Energy Charge in lobster gill, tail muscle or hepatopancreas even after 96 hr exposure. Gill Na^+ K^+ATPase activity was significantly inhibited after 72 hr exposure. Gill Zn levels remained elevated after 168 hr in clean seawater and ATPase remained inhibited. (St. Andrew's).

The tolerance of polychaetes to organochlorine pesticides may be related to their ability to maintain their energy requirements anaerobically or aerobically. Worms were exposed to Endosulfan for 96 hr under aerobic or anoxic conditions. No AEC differences were found in untreated animals held aerobically or anoxically. In anoxically exposed animals Endosulfan caused a decrease in AEC from 0.80 to 0.69. (St. Andrew's).

A program has been initiated on monitoring AEC in local clams and mussels. No temporal or spatial trends have been detected yet (St. Andrew's).

Relatively high levels of polycyclic aromatic hydrocarbons were detected in lobster hepatopancreas and tail muscle of American lobster (Homarus americanus) collected in the vicinity of a coal-coking plant which discharges its effluent into Sydney Harbour, Nova Scotia. Levels in the hepatopancreas were much higher than levels in the tail meat. A survey was carried out to determine the extent of the contamination. Results to date indicate that the contamination does not extend beyond the harbour. (Halifax).

Continued studies of American lobsters (Homarus americanus) contaminated with cadmium (Belledune Harbour, New Brunswick) indicated that highly contaminated animals rarely appear outside of the harbour. This is contrasted to the finding that lobsters tagged within the harbour in the summer are recaptured outside of the harbour at a frequency which suggests that at least 25% of the tagged animals wander out of the harbour. Analysis of the data suggests that many of the animals which were tagged were animals which wandered into the harbour during the summer and were captured (Halifax).

Tissues from cod (Gadus morhua) exposed to dietary di-2-ethylhexyl phthalate (DEHP) were analyzed for DEHP residues. Liver levels of DEHP in untreated females ranged from 0.81-2.24 µg/g (wet wt.) while liver levels from females fed 1000 µg DEHP/g food ranged from 4.21-19.8 µg/g. DEHP had no major effects in male fish but significantly altered steroid hormone metabolism in both head kidney and ovary of female fish (Halifax).

Studies of the distribution, behaviour and transport of dissolved and particulate metals in the St. Lawrence estuary and the Gulf of St. Lawrence have continued. Some work has also been undertaken on the distribution of trace metals in the Bay of Fundy (COD/BIO).

3. During August through to December, 1981, flounders from Passamaquoddy Bay, New Brunswick, exhibited signs of fin rot. Live specimens were sent to the Fish Disease Section for examination (St. Andrew's).

4. Work has continued on the sources, sinks and transport of organic carbon in the St. Lawrence estuary and Gulf of St. Lawrence. A program for the monitoring of the particulate organic carbon content of the St. Lawrence was initiated under the auspices of SCOPE/UNEP. (COD/BIO).

   Baseline measurements were made of the levels of low molecular weight hydrocarbons and petroleum residues on the Grand Banks of Newfoundland. Work on low molecular weight hydrocarbons and petroleum residues in the eastern Canadian Arctic was also continued (COD/BIO).

5. Environmental monitoring of radionuclides in the Bay of Fundy in the vicinity of the Pt. Lepreau nuclear generating station was continued in 1981. A report on the first year's results (BI-R-81-10) has been written (COD/BIO).

6. A review of all literature on Beluga and Bowhead whales has been prepared and the gaps in the basic biology of the animals identified. The study of the biology of whales in the Beaufort Sea/Mackenzie Delta are being carried out in order that these animals and their habitat be protected from negative impacts of hydrocarbon exploration and exploitation (FWI).

   The concentrations of Pb, Hg, Se, Zn, and Cd are being measured in the liver, kidneys and muscle of narwhals from the eastern Arctic and the results evaluated in relation to pollution (FWI).

7. Studies on hepatic mixed function oxidase induction in fish following exposure to some aromatic hydrocarbon based PCB replacements have been carried out. Enzymic activities in a large group of uncontaminated fish were inversely related to body weight, probably by a weight-specific metabolic activity relationship.

   Mixed function oxidase levels in sculpins (Myxocephalus spp.) sampled from various areas which were known to differ in the extent of PCB contamination were well correlated with tissue burdens of PCB (MEL).

   Mixed function oxidase (MFO) enzyme activity has now been demonstrated in at least three species of bivalves, animals which were previously reported (including by us) to be "difficient" in this enzyme system. Activity was highly variable in each species. Enzyme induction was not observed in mussels chronically exposed to petroleum, suggesting the limitations of using MFO as a monitoring tool for hydrocarbons in this species (St. John's).

   A three to four fold increase in MFO activity was observed in the liver of commercial size codfish chronically exposed to a low level of petroleum hydrocarbons. These results are of particular interest since induction was observed under two potentially detracting conditions (a) low winter temperature and (b) gonad maturation (St. John's).

   (a) A variety of natural compounds has been determined to be good candidates for chlorination derived mutagenesis. Preliminary evidence indicates that some of these compounds are not halogenated derivatives but oxidative by-products of the chlorination process (St. John's).

(b) Ongoing research continues to indicate that PAH enriched fractions of petroleum hydrocarbons do not have a significant mutagenic potential. Experiments in 1981 involved the testing of photoxidized residues of Venezuelan crude. Meanwhile, the introduction of nitro groups to complex mixtures of petroleum hydrocarbons has been shown to generate potent mutagens. (St. John's).

8. Field studies of the Amoco Cadiz oil spill in Brittany have focussed on the distribution of oil in sediments from various locations. Oil associated with fine-grained sediments from low energy environments persists for several years though modified by degradative processes, coarser sediments, oil moved rapidly to lower strata with less degradation. (MEL)

A new programme to study deep ocean ecological processes which are relevant to the disposal of radioactive waste in the deep sea has been started. The program should be well under way by the end of 1982. (MEL)

9. Atlantic cod (Gadus morhua) were exposed to 150-300 ppb water extract of Venezuelan crude oil in a flow-through system over a 13-week period at 8-12°C. Growth, hematological and histopathological indices were studied. During the experiment total body weight increased 79% in control and 11% in oil-treated fish over the initial body weights. This difference is most likely a direct result of decreased food intake in oil exposed cod. Somatic indices for heart and gall bladder were significantly different between the two groups. Histopathological changes in oil-treated fish included increased pigmentation in the skin, diminution in size of white muscle fibers, fused and/or endematous gill filaments and a decrease in size of liver cells. There were little doubt that Atlantic cod exposed to a water extract of Venezuelan crude oil showed signs of morphological and physiological stress. (St. John's)

10. "Background levels" of hydrocarbon degrading bacteria were found in a number of sediment samples taken from the Grand Banks and along the Labrador Coast. (St. John's).

Total lipids, phospholipids, lipids by class and fatty acids have been investigated in the livers of cod (Gadus morhua) and flounder (Pseudopleuronectes americanus) following exposure to Venezuelan crude oil. Cod was exposed to 150-300 ppb of oil in sea water for 24 weeks and flounder was exposed to oiled sediments (2-3 mg of oil per gram sediment) for 16 weeks. Total lipids were not significantly altered in any species except female cod where the lipid values increased. Total phospholipids increased in the males and females of both species. In the lipids by class, triglycerides decreased and free fatty acids and wax esters increased, whereas steryl esters decreased in cod but increased in flounder. Essential fatty acids in the C_{16}, C_{18} and C_{20} series were altered in both species. Preliminary results indicate that long term exposure to petroleum hydrocarbons can affect various aspects of lipid metabolism in marine fish. (St. John's).

11. Most, if not all, of a marine teleost's requirements for Zn^{2+} must be met by an adequate diet. Therefore, experiments are being conducted to determine the factors involved in regulating the uptake of Zn^{2+} from the flounder's gastrointestinal tract. The ability of the digestive tract to absorb Zn^{2+} varies with the season, with the maximum rate occurring during the summer months when the maximum rate of feeding and somatic growth occurs. Absorption across the digestive tract appears to be a two step process, with Zn^{2+} first absorbing to the mucosal cells and subsequently being transferred to the blood stream. Zn^{2+} absorption and transfer across the tract can be inhibited by a variety of metals including Cu^{2+}, Hg^{2+} and Cd^{2+}. (St. John's)

Denmark
(A. Nielsen)

1. The Marine Pollution Laboratory has continued monitoring activities during 1981. Bimonthly collections of samples for determination of concentrations of nutrients in sea water, phytoplankton primary production, and composition and abundance of phytoplankton and zooplankton have been accomplished at ten locations in the Belt Sea, the Sound and the Kattegat.

   Samples for determinations of the content of trace metals, PCB and DDT in flounder and sediments have been collected at two locations in the Great Belt and the Sound.

2. As for the North Sea, extensive surveys have been carried out on the west coast of Jutland with a view to determine the level of mercury in common mussel and flounder.

3. Studies on biological effects have been carried out with a view to investigate how cadmium is assimilated by Mytilus edulis and how cadmium affects the metabolism of mussels. Parallel with these studies the feasibility to incorporate biological effect studies in existing monitoring programmes in the coastal zone have also been investigated.

4. A study on the input of organic material and nutrients to the Belt Sea, the Sound and the Kattegat was initiated in 1981. The study is a follow up of a five year investigation of the exchange of water and matter through the Danish Straits (the Belt Project). According to the present plans, the study will be followed by similar work on inputs of harmful substances to the coastal zone.

5. Episodes of unusual plankton blooms and low dissolved oxygen concentrations in the bottom water of the transition area between the North Sea and the Baltic Sea have been reported for several areas in Danish waters.

6. Funds have been granted for the establishment of a fish pathology group affiliated with the Danish Institute for Fishery and Marine Research. This means that surveys of fish pathology and diseases will be carried out on a regular basis in the future.

Dissolved oxygen, fish mortality and plankton blooms in Danish waters 1982. The monitoring activities carried out by the Marine Pollution Laboratory in open Danish waters show that unusual high concentrations of nitrogenous, nutrients were present in the surface layer in Danish waters in the period December 1980 - March 1981. The phenomenon was especially pronounced in the Belt Sea. Most likely the high concentration of nitrogen in surface layers, was due to an abnormally great run-off of fresh water from land during winter, 1980/81.

In regard to dissolved oxygen unusually low concentrations of dissolved oxygen were observed in bottom waters, in Fehmarn Belt in July 1981. In the Sound, and the southeastern part of the Kattegat, the concentrations of dissolved oxygen were lower than normal; however, no impact on the bottom fauna was observed. Effects on the bottom fauna due to low oxygen concentrations were neither observed in the western part of the Kattegat, the Great Belt or the Arkona Basin, Figure 1.

Mass mortalities of fish (dab, flounder, cod, sea scorpion, common shrimp) have been reported from four locations in the Belt Sea, and single locations in the Kattegat and the North Sea (Figure 1). With the exception of the North Sea incident the cause of fish mortality has been reported as suffocation due to low dissolved oxygen concentrations in bottom waters. In the case of the North Sea, the cause of the fish mortality was reported as suffocation due to low dissolved oxygen concentrations in water in combination with the presence of a dinoflagellate, Gyrodinium aureolum, in the water masses.

In autumn 1981, unusual dinoflagellates were observed in the Kattegat. Cruises were carried out in September, October and November 1981 with a view to explain the course of the plankton blooms. One of the dinoflagellates, Prorocentrum minimum var. triangulatum, has not been recorded earlier in Danish waters, while the other one, Gyrodinium aureolum, is common in the North Sea - Skagerrak area.

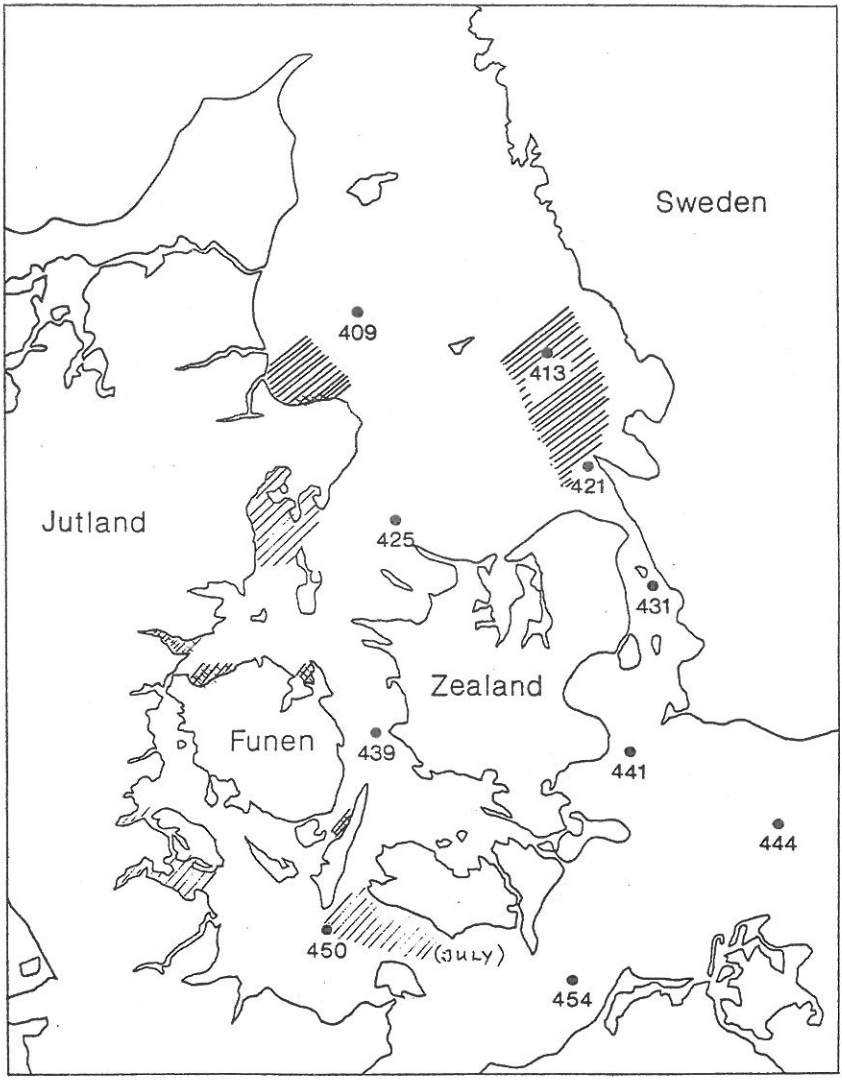
Denmark (Greenland)
(M. Hansen)

1. Monitoring studies continued at a disposal site for tailings produced by a lead-zinc mine and mill in West Greenland. Lead, zinc, cadmium, and copper are monitored in sea water, sediments, and marine organisms, including fish, seals, shrimp, mussels and brown algae.

2. The project studying the natural variation in element levels in indicator organisms was continued. The organisms studied are mussels (Mytilus edulis) and brown algae (Fucus vesiculosus, Fucus distichus, and Ascophyllum nodosum). The samples are analyzed for a suite of elements by atomic absorption spectrometry and instrumental neutron activation analysis. Results from analysis of variance on the first years (1980) samplings show that:

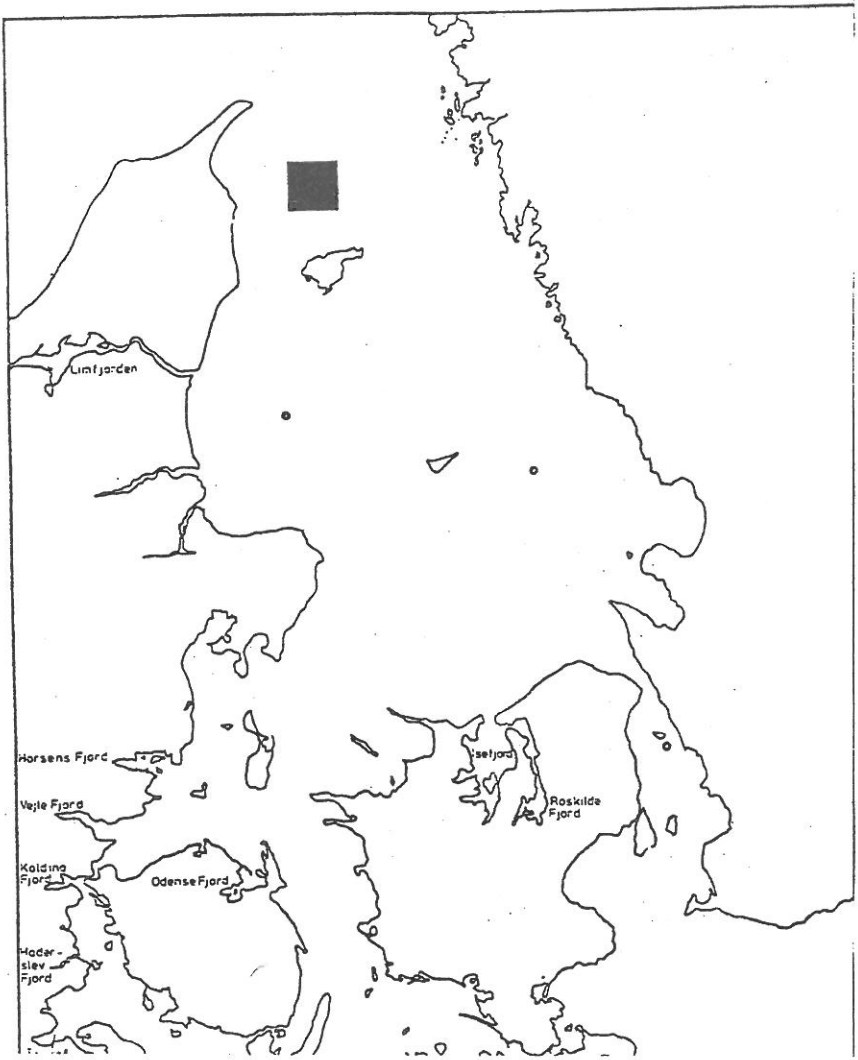
   2.1 For brown algae there is, for most elements, a significant interaction between the effects and species and locality. This means that the different species of algae give different answers when used to compare pollutant levels at different localities.

Figure 1 (pp 9-13)



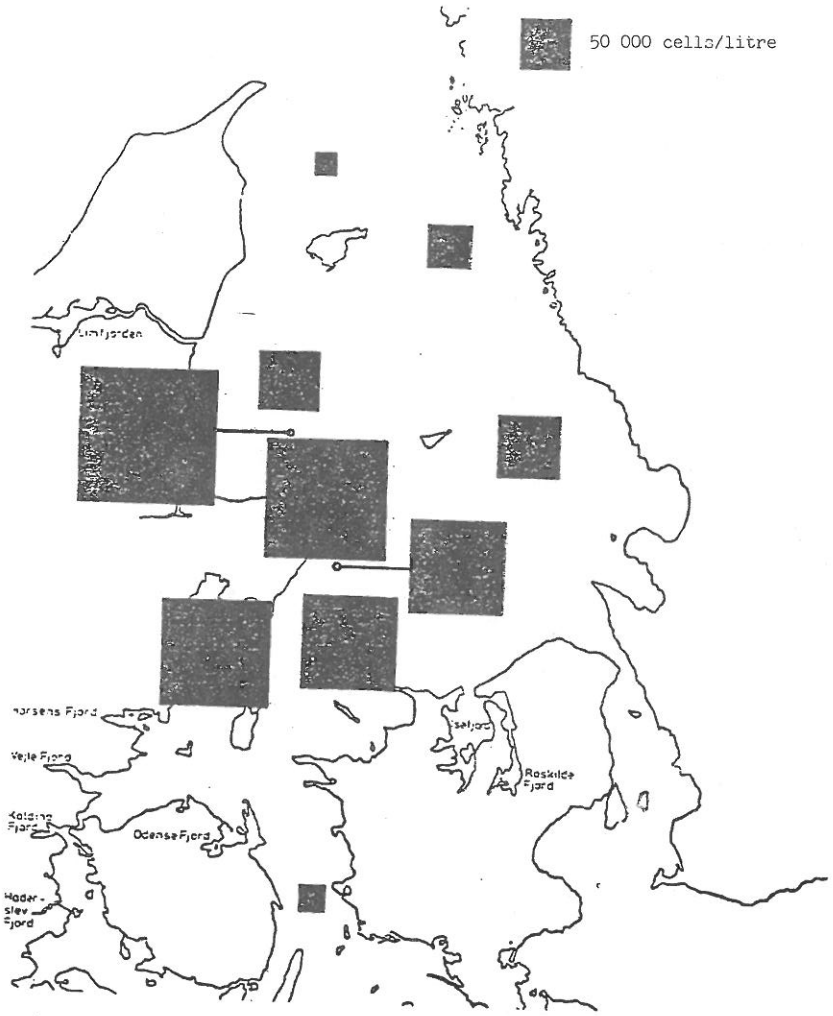
LOW DISSOLVED OXYGEN CONCENTRATIONS IN THE BOTTOM WATER, SEPTEMBER 1981.

FISH MORTALITY IN SEPTEMBER/OCTOBER 1981.

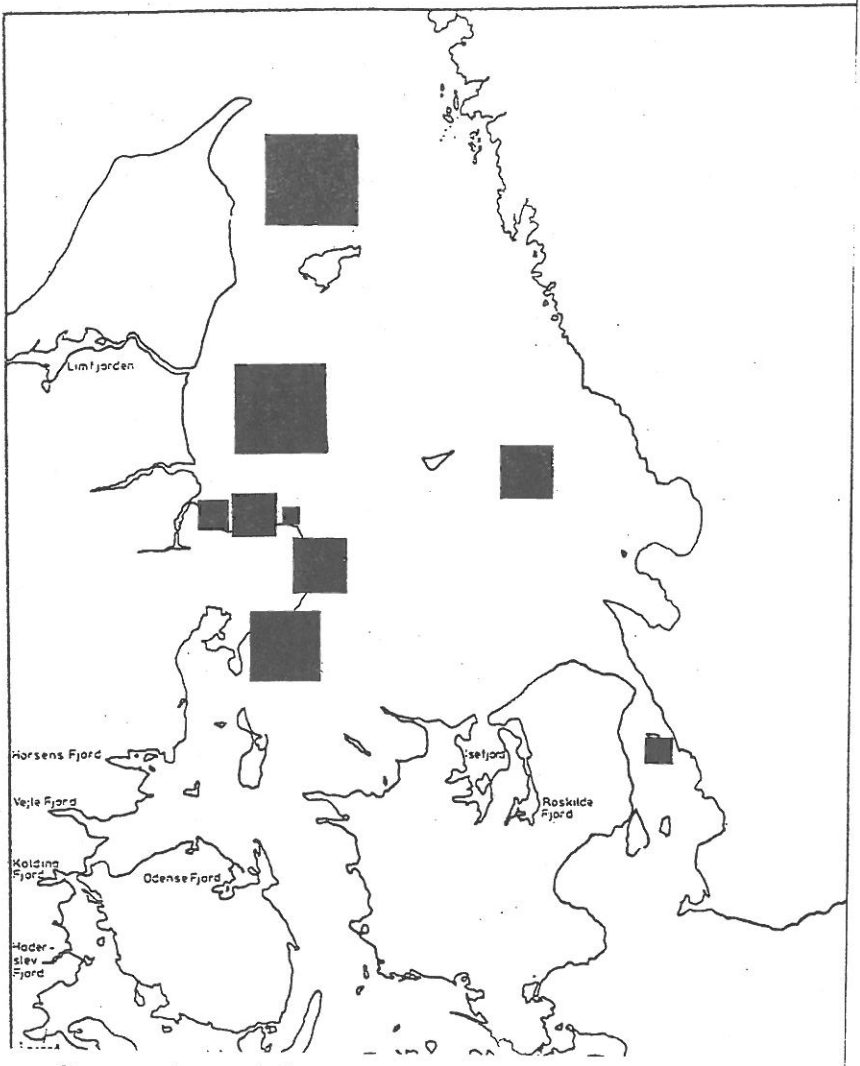


Gyrodinium aureolum: cell concentrations in the period of 21-22 September 1981

50.000 cells/litre

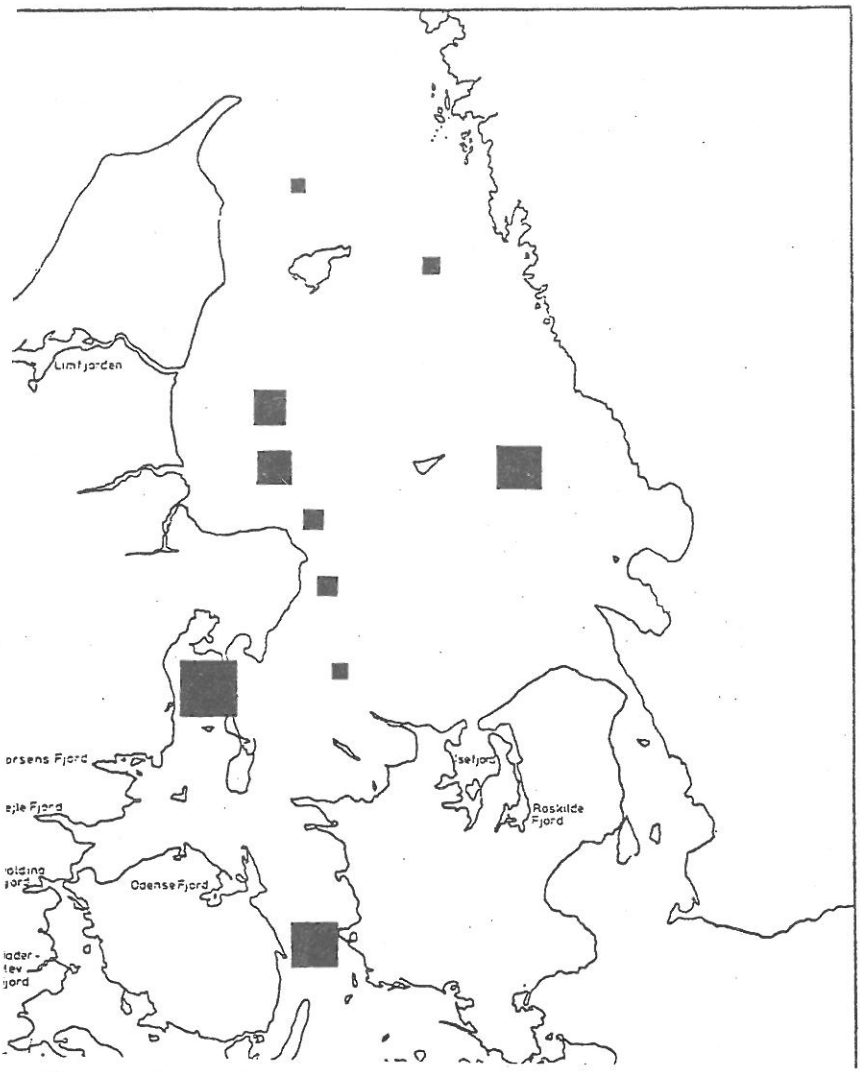


Records of the planktonic dynoflagellate Gyrodinium aureolum in October 1981. This algae may occur in very high numbers and is then poisonous to fish. The gills are damaged which causes the fish to suffocate.



Prorocentrum minimum: Cell concentrations found in the period of 12-22 September 1981

50 000 cells/litre



Prorocentrum minimum: Cell concentrations found in the period of 12-14 October 1981

50 000 cells/litr

2.2 No matter if shell length or freeze dried weight of soft parts are used as a stratification variable, there is a significant interaction between the size parameter and locality. This shows that the slope relating the size of mussel to element concentration are different from locality to locality and this further shows that different sizes of mussels may give different answers when used to compare pollutant levels at localities.

Finland
(T. Melvasalo and P. Tulkki)

1. MONITORING OF WATER QUALITY. Finland is participating in the monitoring of the Baltic Sea in the framework of Helsinki Commission. In this work Finland and the USSR are responsible for monitoring of the Gulf of Finland. Sweden and Finland are responsible for the Gulf of Bothnia. Moreover, the same states conduct larger bilateral monitoring programmes in the Gulfs. The bilateral work with Sweden and the USSR also includes data on loading of pollutants.

   Coastal waters have been intensively monitored by the water authorities and by authorized local laboratories. Discharges of selected pollutants from rivers have been monitored as well.

2. OTHER POLLUTION STUDIES. Current measurements and studies on heat exchange between water and air have been continued off nuclear power plants since 1972. The studies have been planned and conducted in such a way, that they are applicable also in other situations. Essential work has now been finalized and the ten year study will be completed during the present year.

3. Studies on nitrogen fixation have been continued by publishing data from the Gulf of Bothnia. This study was started in 1974 and will still continue one or two more years.

4. A decrease in the Baltic herring stocks has been found in the Bothnian Sea. Because some pollution factor may be involved, a series of studies have been started.

5. Sedimentological studies on long term variations in the Baltic Sea have been continued. The studies include analyses of heavy metals, halogenated hydrocarbons, and radionuclides from postglacial strata and dating of sediments. In this connection a cooperative project with scientists from GDR has been started.

6. In the bilateral cooperation with Sweden in the Gulf of Bothnia, some work has been done in the field of material balances of nutrients and harmful substances. Data collected from both countries have been put together to find out existing gaps in the knowledge on inputs and outputs of nutrients and harmful substances. The goal of the work is to get information on the fate of substances in the Gulf of Bothnia and to evaluate the degree of human influence in the pollution.

7. Several methodological chemical studies are continuing and have been started in 1981. Of these should be mentioned the development of concentration methods for heavy metals and halogenated hydrocarbons from sea water, development of analyses for Al, As and toxaphen.

8. Stands of bladder wrack, Fucus vesiculosus, have been studied in the coastal waters of southern Finland. The amount of Fucus has strongly decreased and wide alterations in the littoral ecosystem have taken place during past years. The phenomenon has created intensive studies.

9. A comprehensive study concerning effects on the littoral ecosystem of waves generated by large passenger ships in the Archipelago Sea has been completed. Other biological studies started or still continuing are, e.g., the study or suitability of meiofauna for water quality monitoring in the Bothnian Bay; a research project on methods for the use of macroalgae as indicators of heavy metal pollution; the use of bacterial uptake of glucose and degradation in monitoring of waste waters of the cellulose industry; and the study of the benthos as an indicator of long term changes in the deep basins of the Baltic.

10. TWO SYMPOSIA. In June there was a Finnish-Swedish Symposium on the Gulf of Bothnia held in Luleå, Sweden. The organizer was the Finnish-Swedish Committee on the Gulf of Bothnia. Most of the contributions dealt with pollution loads, state of the Gulf, and effects of pollution in the Gulf.

    In September there was held a Symposium on the biology of the Gulf of Finland with an aspect of pollution included. This symposium was organized by the Finnish-Soviet Working Group on the Gulf of Finland. It was held in Pärnu, Estonian SSR.

    Publications of the lectures from both symposia will be published during 1982 in Sweden and the USSR.

France
(C. Alzieu)

1. Surveillance. Dans le cadre du Réseau National d'Observation de la qualité du milieu marin (R.N.O.) 43 zones littorales ont été régulièrement échantillonnées pour détermination des paramètres physicochimiques des eaux et des teneurs en micropolluants dans les eaux, les sédiments et les organismes vivants.

    L'évolution à long terme de la contamination en hydrocarbures des zones qui ont subi des accidents pétroliers importants, a été poursuivie en 1981 et un programme de "veille écologique des côtes bretonnes" mis en place.

    La baie de Seine a fait l'objet comme les années précédentes d'une surveillance écologique particulière en relation avec les rejets de phosphogypse.

2. Etudes et recherches

2.1 Programmes interdisciplinaires. Une étude à laquelle participent plusieurs organismes scientifiques, et consacrée aux écosystèmes perturbés en Manche centrale a été mise en oeuvre tandis qu'étaient examinées les possibilitiés de réaliser un programme comparable sur le thème des intéractions continent-océans.

2.2 Etudes de zones intégrées. Une zone littorale (Nord - Pas-de-Calais) et un estuaire (Loire) font l'objet d'une étude pluriannuelle destinée à connaître les apports polluants et leur devenir dans l'environnement marin.

2.3 Ulcerations et nécroses de poissons. Une campagne à la mer avec participation de huit chercheurs étrangers s'est déroulée en octobre et novembre en Manche et dans le Pas-de-Calais afin d'établir un inventaire des maladies, anomalies et parasites de poissons d'intérêt commercial. Des prélèvements de tissus (biopsies) ont été effectués en vue d'examens histologiques.

2.4 Thermoecologie. L'étude expérimentale des effets des chocs thermiques a été poursuivie sur:

un dinoflagellé responsable d'eaux rouges S. faeroense,
un copépode de zone intertidale T. brevicornis,
et les différents stades de la post larve d'A. anguilla.

Le suivi écologique des zones d'impact des centrales électronucléaires installées sur le littoral de la Manche et de l'Atlantique a été poursuivi et complété par l'étude des effets des circuits de transit d'une centrale électrothermique sur l'ichthyofaune d'un estuaire.

2.5 Ecotoxicologie. Les effets toxiques des substances métalliques (Cu, Zn) et organométalliques contenus dans les peintures antifouling, ont été étudiés à court terme sur les larves et à moyen terme chez les huîtres adultes C. gigas.

Des essais en vue d'une normalisation des tests biologiques destinés à caractériser la toxicité des produits destinés a la lutte contre les hydrocarbures, ont été poursuivis en collaboration avec des chercheurs du Royaume-Uni.

2.6 Eaux rouges. La collecte d'informations nécessaires à l'établissement d'un inventaire des espèces planctoniques responsables d'eaux rouges a été complétée par des examens microscopiques et des tests de toxicité en vue de mettre en évidence la présence de mytilitoxines.

Federal Republic of Germany
(G. Weichart)

1. In accordance with national and international monitoring programs, nutrients, oxygen, heavy metals, chlorinated hydrocarbons, and petroleum hydrocarbons were monitored in the German Bight as well as in the Western Baltic Sea.

2. Studies on the small and medium scale variability of nutrient distributions were undertaken in the Baltic Sea with the chemical profiler system in June 1981. The last cruise was a joint expedition with the Institute of Thermo- and Electrophysics from the Estonian Academy of Sciences (Tallinn). Preliminary results show strong horizontal inhomogeneities above and below the halocline. Variations in physical properties were always accompanied by corresponding variations in chemical parameters. Some nutrients, however, showed larger variabilities not related to variations in physical parameters, thus indicating biological or chemical processes.

3. Oxygen measurements in offshore areas of the German Bight (130 km NW of Helgoland) revealed a decrease in near bottom waters down to less than 25% saturation. An area of several thousand km^2 was affected.

4. Trace metal surveys in Baltic waters were conducted during a cruise in June 1981 including the elements Zn, Cd, Cu, Ni, Fe, Mn, As, Se, Ge, and Sn. Special emphasis was given to speciation problems and processes at anoxic interfaces.

5. Organic substances were investigated in the Baltic Sea during cruises in June 1981. The results showed phenanthrene, fluoranthrene, pyrene, and chrysene as the principal components of the fluorescent hydrocarbon fraction indicating that a considerable portion of fluorescent hydrocarbons normally attributed to oil pollution are high temperature combustion products which may well enter the sea via atmosphere. Among others, diphenyl sulfone was found in surface and deep waters in concentrations sometime approaching 100 ng dm^{-3}. Its origin is unknown, but the compound is known to be used as an ovicide, especially against eggs and larvae of mites.

6. The determination of chlorinated hydrocarbons in fish was continued as in 1980. PCB analyses related to wet weight and also the fat weight were carried out in 10 samples of the filet of flounder (Platichthys flesus) caught in June in the Ems-estuary.

   Secondly, PCB was determined in filet and liver of 10 plaice-samples (Pleuronectes platessa) caught in May in the Elbe-estuary.

7. Studies about species composition, abundances and fluctuations of the benthic macrofauna have been conducted in the mud area of the inner German Bight. An area of about 50 km^2 can be characterized by an impoverished macrofauna. The impoverishment is due to lack of oxygen at the bottom.

8. Epidemiological studies on occurrence and abundance of fish diseases (fish and shellfish) in the southern North Sea and western Baltic were continued. Cruises were carried out in the southern North Sea in January, June and October. For the investigation of seasonal fluctuations of fish diseases, monthly surveys in the titanium dioxide dumping area and the Elbe-estuary were performed.

   In July a cruise was carried out in the western Baltic. In connection with the epidemiological studies investigations were continued on bacteriological and virological aspects of diseased fishes.

   Studies on the etiology concentrated on histological investigations of fish and shellfish diseases and on the role of heavy metals in skeletal deformities of cod (Gadus morhua).

9. Investigations were carried out to assess, in conjunction with information from laboratory experiments, pollution effects on marine biota:

   9.1 Natural multispecies bacterial communities, in a resting state and and at low initial densities, were used to study effects of dissolved mercury on nutrient absorption.

   9.2 Running ripe Baltic Flounder (Platichthys flesus) were used to acquire knowledge of the relationship between ovary contamination levels of bioaccumulating substances (chlorinated hydrocarbons and heavy metals) and reproductive success.

10. Laboratory investigations about the effects of low oxygen in sea water on the mortality of diseased and healthy dab (Limanda limanda) were started. Investigations of accumulation of heavy metals in shrimps (Leander adspersus) and the influence on their reproduction were continued.

Iceland
(J. Olafsson)

1. Trace metals. A programme on trace metals in sea water in the region of the Mid-Atlantic Ridge was started by investigating the area north of Iceland.

2. Mussels. Work on trace metals in mussels was continued. Particular attention was given to the accumulation of trace metals in Mytilus edulis, caged in various environments, during the first year of life.

3. Nutrients. As in previous years, monitoring of nutrients was continued in coastal and shelf waters, by work at numerous stations during the period from April to August. Particular attention was paid to variations in connection with spring phytoplankton productivity and environmental conditions at the time of spawning and hatching of gadoid fishes.

Ireland
(M. Parker and M. O'Sullivan)

1. Department of Fisheries and Forestry.

   1.1 Fish and shellfish Quality monitoring

   Monitoring of levels of six heavy metals in two species of fish and in Mytilus edulis for national purposes and as part of the input to ICES and Oslo and Paris Commission programmes continues.

   1.2 Fish Pathology

   A trawling cruise of the East Coast, including areas known to have higher levels of contaminant inputs, was undertaken during the summer. The results have been presented to ICES for the appropriate Working Groups.

   1.3 Collection of observations on algal blooms on the South Coast continue. Following a pattern established over the last five years, diatom blooms occurred in the mid-south coast region during June (with an admixture of Phaeocystis) and in July-August, blooms in Gyrodinium aureolum affected the south-west, causing mortalities at two salmonid culture installations. The degree of mortality was not as severe as in previous years. Shellfish from affected areas were assayed for PSP with negative results (as in previous years). While evidence is growing for a basically oceanographic cause of these events (rather than pollution; the events are linked to coastal frontal systems) the exact causes cannot yet be determined.

2. University of Dublin, Trinity College; Environmental Sciences Unit.

   Work continues on the development of quality indices for estuarine management. Studies of metal levels in various molluscan species in Dublin Bay and elsewhere on the east coast and on their biological effects continue. A project utilizing physiological and bioassay techniques (including Scope-for-Growth) is commencing.

3. University College, Galway, Faculty of Marine Science

   An EEC sponsored project on the degradation of soluble biologically active fractions of crude oil and its effects on microbial activity is in progress at the Microbiology Department. Bag-enclosure studies are being carried out at sea in conjunction with chemostat experiments in the Laboratory.

4. Geological Survey Office

   Marine gravels from the Kish Bank will be used to provide infill for a tidal scour close to the Kish Bank Light House. Trial dredging of Lithothamion at Kilkieran Bay, Co. Galway is commencing but figures for tonnages are not yet available. A zero return for aggregate extraction is accordingly made for 1981.

Netherlands
(S. J. deGroot)

1. In the framework of development aid, the problems of bordique fishery in the Lake of Biban (Tunisia) were studied and suggestions for improvement have been made.

2. High mercury contents around 1 mg/kg in pike and pike-perch from the "Oude Veer" indicated a contamination source in that vicinity.

3. The Dutch government established a PCB tolerance level of 5 mg/kg for eel. The PCB contents of eel caught in the rivers Rhine and Meuse exceeded this level, making them unfit for human consumption. Waste of a tetrachloroethene industry in Germany caused high contents of HCB (2-3.5 mg/kg), OCS (0.5 mg/kg) and HCBD (1.3-1.7 mg/kg) in eel from the river Rhine. Analysis of cod and hake livers have shown constant contamination levels for PCBs and pesticides in the North Sea and the Atlantic Ocean since 1974.

4. Biodegradation studies of organic model compounds have continued with the use of chemostat and batch systems.

5. In relation to biological effect monitoring the phytoplankton in the Dutch coastal waters have been studied. The river Rhine inflow strongly influences salinities and nutrient contents in this area.

6. The results of sanitary shellfish control were well within the requirements of the water quality standards in shellfish culturing areas.

7. In September a gastro-enteritic shellfish poisoning occurred in the Waddensea and the western part of the Oosterschelde. Suspected dinoflagellates detected were Prorocentrum micans and Dinophycis acuminata.

8. In regard to parasitological and pathological research, several aspects of fish and shellfish infections were studied. However, the main topic for 1981 was shellfish and especially the problem of the presence of a new oyster disease (microcell disease, Bonamia ostreae) in the oyster culture area of the Oosterschelde. Based on the 1980 studies, no oyster culture was permitted on the Yerseke Bank for 1981, and the infected area was cleaned of the remains of the oyster stocks as far as possible. Despite these protective measures bags with disease-free oysters, placed in spring 1981 as checkpoints on the Yerseke Bank, showed the disease again during the autumn. The Yerseke Bank is considered therefore still as infectious and makes a start of a new set up of oyster culture on that locality for 1982 impossible.

NORWAY

(P.T.Hognestad + K.Palmork)

1. Field Programmes

1.1 Investigations on the environmental qualities in the Skagerrak in two sections (Torungen-Hirtshals, Oksøy-Hanstholm) between Norway and Denmark were carried out with 11 surveys throughout the year. Measurements were made of temperature, salinity, oxygen, nutrients. (Biological Station Flødevigen).

1.2 Experiments have been conducted in plastic enclosures in Lindåspollene, western Norway, designed to measure the effect of oil on biological processes in and the species composition of pelagic communities. (Institute of Marine Biology, University of Bergen).

1.3 Measurements have been made of primary production and the phytoplankton species composition and physiological condition have been studies in relation to environmental conditions at Kårstø, near Stavanger, an area under development for the oil industry. (Institute of Marine Biology, University of Bergen).

1.4 Marine fouling on oil rigs and buoys has been studied in connection with the preparation of an atlas of potential fouling organisms in the North Sea. (Institute of Marine Biology, University of Bergen).

1.5 Within the framework of the State pollution monitoring programme, sponsored by the Ministry of Environment, baseline and monitoring studies have been carried out in about 15 heavily polluted coastal areas. The investigations have focused on surface water quality (Phytoplankton biomass measured as chlorophyll a), structure of shallow water and soft bottom communities and the occurrence of metals, polycyclic aromatic hydrocarbons and other pollutants in biota and sediments. Other field studies include the evaluation of existing or planned effluents from industry and municipalities. Most of the studies include standard hydrography and measurements of plant nutrients.(Norwegian Institute of Water Research).

1.6 In connection with the problems of water quality criteria and guidelines for nutrient loading, work has continued with respect to the possibility of establishing an eutrophication model for fjords. This work is also connected with the re-evaluation of treatment demands for municipal sewage discharged to the sea.(Norwegian Institute of Water Research)

1.7 Studies in the naturally anoxic and extremely stagnant basin Framvaren have continued. The main themes are: Reference or baseline levels of pollutants and microbiological and chemical processes in water and sediments and in the transition layer between oxic and anoxic water. Scientists from other countries are welcome to participate.(Norwegian Institute of Water Research).

1.8 Monitoring of the environmental qualities of selected Norwegian fjords from Stavanger to Varangerfjord were carried out. The fjords were selected to represent different types of environmental stress conditions; i.e. industrial and domestic loads. Measurements were made of salinity, temperature, nutrients, oxygen and turbidity. (Institute of Marine Research).

1.9 Environmental quality of coastal sea water. This programme continued for the seventh season. The organic load of the Baltic current is being investigated from the Øresund through the Kattegat, Skagerrak and along the western Norwegian coast. Recordings are made of particulate matter, nutrients and temperature, whereas primary production indices are measured at intervals. (Institute of Marine Research).

1.10 Effects of the water soluble fraction (WSF) of Ekofisk crude oil has been studied on eggs and early larval stages of cod. The work was concentrated on sublethal effects of low levels of dissolved oil hydrocarbons (50-250 ug/l) by recording mophological aberations, weight and growth rates, as well as feeding rates and buoyancy. (Institute of Marine Research).

1.11 Study of the metal organic complexes in the Oslofjord with special reference to their release and stability under different redox conditions. (Institute of Biology and Limnology, University of Oslo).

1.12 The role of metal organic complexes in the metal flux across the sediment water boundary. (Institute of Marine Biology and Limnology, University of Oslo).

1.13 Carbon, nitrogen, phosphorus and trace metal budget of the inner Oslofjord. (Institute of Marine Biology and Limnology, University of Oslo).

1.14 Chemical and physical changes during early diagenesis of sediments of inner Oslofjord and Drammensfjord with special reference to metals and organic compounds including PCBs and DDTs. (Institute of Marine Biology and Limnology, University of Oslo).

1.15 Field experiments were continued on the effect of Ekofisk crude oil on the recruitment of benthic organisms. (Institute of Marine Biology and Limnology, University of Oslo)

1.16 The patterns of distribution of various chemical components, macrobenthos and benthic foraminiferes in the Oslofjord were studied with future influence of a new sewage treatment plant in mind. (Institute of Marine Biology and Limnology, University of Oslo).

1.17 The effect of eutrification and pollution on the structure of fish communities in the Oslofjord is currently under investigation. (Institute of Marine Biology and Limnology, University of Oslo).

1.18 Baseline surveys of petroleum hydrocarbons in sediments were performed at Tromsøflaket, Haltenbanken and Traenabanken off NW Norway. These banks are potential oil fields where exploratory drilling is started or planned. (Institute of Marine Research).

2. Laboratory Assays

2.1 Behaviour of cod in water with gradients of the soluble fractions of Ekofisk crude oil was studied in special constructed aquariums. (Biological Station Flødevigen).

2.2 Study of effects of water with soluble fractions of crude oil was carried out on diluted natural populations of phytoplankton and in cultures of single species. (Biological Station Flødevigen).

2.3 Embryological material from sea urchins and marine fishes is used to study the effect of Ekofisk oil, aromatic hydrocarbons and oil dispersants. (Institute of Biology and Geology, University of Tromsø).

2.4 Long term studies of the effect of low oil concentration on a simulated littoral rock community will start in 1982. The experimental communities have been established over 2 years in four 50 m^3 basins. Similar studies are planned with soft bottom communities. (Norwegian Institute of Water Research).

2.5 There have been studies on effect of oil on the growth rate of marine diatoms in outdoor dialysis cultures and development of algal bioassays for testing the toxicity of hydrocarbons. (Institute of Marine Biochemistry, University of Trondheim).

2.6 Accumulation and elimination of naphtalene, phenanthrene benzo-a-pyrene in flounder (Platichthys flesus) was studied with C_{14} labelled compounds. The fate of phenanthrene was also studied in coral species (Haemulon scirius, Macrocalista maculata, Diploria strigosa). (Institute of Marine Research, Bergen).

2.7 A biochemical approach was made to assessment of effects of environmental rythms and oil related pollution on the metabolism of certain polychaete worms, especially the non-opportunistic species Glycera alba. (Institute of Marine Biology and Limnology, University of Oslo).

2.8 Studies were made on lethal and sublethal effects of Ekofisk crude oil and dispersants alone and in combination on flounder. (Institute of Marine Biology and Limnology, University of Oslo).

2.9 Laboratory studies were made on the possible influence of oil contaminated sediment on the activity pattern of the common goby Pomatoschistus microps. (Institute of Biology and Limnology, University of Oslo).

POLAND

No report received.

Portugal
(M.J. Bebianno, A. Ferreira, and C. Lima)

1. The environmental study of the Tejo estuary was continued:

1.1 Water quality studies: surveys were carried out monthly til July, and every two months until the end of 1981. Since March two new sampling stations were added in the area of higher salinity gradient.

1.2 Sediment dynamic surveys: to collect data for validation of the one-dimensional model which predicts the distribution of suspended mater in the estuary.

1.3 Sedimentology; evolution of the estuary bathymetry: the comparison of the hydrographic plans in the estuary was based on studies done from the end of the XIXth century up to 1964/66. Rates of erosion and sedimentation (cm/year) of the estuary were calculated for 1 km sections along the longitudinal axis of the estuary. The evolution of the areas of the intertidal zones was also studied.

1.4 Indirect estimate of the polluting load to the estuary: the information obtained through the inquiries was duly treated with the assistance of the UNIDO to obtain estimates of raw waste from each industrial unit.

1.5 Activities in field of biology:

1.5.1 Benthic fauna: we have now established a general scheme in regard to the composition of benthic communities, both infralittoral and intertidal, as a first step to understanding the dynamic biological processes on the Tejo estuary. Diversity, evenness, and cluster analyses are being considered and related to the presence of different pollutants.

1.5.2 Oysters: Crassostrea angulata have been transplanted from the Sado to the Tejo estuary and are still alive. Also juveniles from Tejo were found on the station where the experiment was carried out. Transplanted oysters were studied for growth, mortality, sexual cycle, bacteriology, organoleptic analysis and heavy metals and pesticide content.

1.5.3 Other oysters: A survey was carried out of the oyster stocks of the estuary, both intertidal and sublittoral. A considerable number of young oysters were found but few adults. The great majority of these young oysters were of another species, Ostrea edulis, that was not previously recorded from the Tejo estuary.

1.5.4 Scrobicularia plana. Its biological cycle was studied at two stations in the two banks of the estuary.

1.5.5 Crustaceans: For Carcinus maenas, Crangon crangon, Palaemon serratus and Palaemon longirostris, a special study was carried out to investigate seasonal abundance and sexual cycle.

1.5.6 Fishes and ichthyoplankton. Forty-two species of fish are present in the estuary, including three species of elasmobranchs and 39 teleosts. The structure of ichthyological communities are now established. Growth, reproduction, and feeding habits of the more important species present in the estuary were studied.

1.5.7 Food chains. A good picture of the food web in the estuary is now established. An approach is being attempted concerning migrating birds of the estuary reserve.

1.5.8 Phytoplankton. Samples were collected and analyzed of pigments at 20 stations along the estuary, monthly, from January to June, and every two months from August to December. "Experiments of turbidity" were also carried out in the laboratory. Experiments on primary production "in situ" were also carried out. Studies of the red tide, detected in the Tejo mouth in June and July, revealed the cause to be Mesodinium rubrum.

1.5.9 Zooplankton. Monthly cruises were made to collect samples in five estuary stations. Extra trawls were made to collect living matter for respiration experiments and zooplankton grazing.

1.6 Heavy metals in sediments and suspended matter: This study was continued. Determination of the total levels of 12 elements in suspended matter and a core collected in the Tejo estuary as well as Hg in 90 sediment samples.

1.7 Heavy metals in aquatic organisms: Fish, shrimps and molluscs were analysed monthly for heavy metals with special emphasis on mercury.

1.8 Inventory of urban and industrial waste discharges was made after visiting some pollution sources and taking into account that there is a special interest in heavy metals and nutrients.

1.9 Air-water transference of heavy-metals: two surveys were undertaken for the measurement of the pollutant concentration in the estuary.

1.10 Analysis of undisturbed cores of sediment to understand the ways to which man has altered the ecosystem of the estuary.

1.11 Mathematical models: four models were studied: Bidimensional Numerical Model, One Dimensional Model for the Calculation of the Tide and Dispersion of salinity and suspended solids, Dissolved Oxygen Model and Eutrophication Model.

1.12 Physical model: In one section a structure was installed to measure velocities. Due to its length and allocation in an area of low depths, a rectification was made of the adjacent bottoms. The report of the mean velocity diagrams corresponding to the 43 points of another section was elaborated.

1.13 Recreational water-sanitary survey in the Costa do Sol beaches: An information on the results obtained in the bacteriological analysis (total and faecal coliforms, Salmonella) was elaborated, within the aim of the sub project "Sanitary Protection of the Water Uses in the Tejo Estuary Area". In this information the possible causes of the pollution on the beaches were analysed and suggestions were presented concerning immediate, medium and long-term measures to be taken in order to attenuate and to improve the existing situation.

2. A pollution survey takes place in spring in Sado Estuary with the aim of developing criteria for the assessment of environment quality in estuaries. Measurements were made of temperature, salinity, oxygen, nutrients and metals in water.

   Work up of data from previous surveys in Guadiana continued.

3. Monitoring studies at disposal site for urban and industrial wastes in the area of Sines have continued. Monthly biological and physio-chemical surveys were carried out to assess the water quality of the marine environment.

4. Environmental conditions in coastal sea water in connection with fish stock assessment were studied. Several cruises were made in continental coast Azores and Madeira. Temperature, salinity, oxygen, nutrients and pigments were measured.

5. In June/July a special survey was made in order to study a red tide in the outer Tejo estuary (Cascais - Guincho). Temperature, salinity, oxygen, pH, nutrients, suspended particulate matter, BOD, pigments, primary productivity, phytoplankton and zooplankton were studied.

6. Monitoring of fish and shellfish quality: the national and JMG studies have continued. More attention has been paid to the quality of fish and shellfish in industrial areas.

7. In the behalf of the Project COST 47 EEC, investigations of variation of dynamics and productivity of macro- zoobenthos populations (Patella depressa, P. vulgata, P. aspera) were done monthly along the Portuguese coast (north, center, south).

8. Fish diseases in relation to pollution: occurrence and abundance of fish diseases were investigated along the Portuguese coast.

Spain
(A. Alvarez)

1. Significant work reported included the following:

   Gonzalez, N; Cabanas, J. M.; Iglesias, M . L. and Nunes, M. T. "Contribution to a study of Ria de Betanzos (NW Spain) II. Bol. Inst. Esp. Oceanog: 6 part 1 no. 286.

   Braun, J. G. "Study on production in Canary Island waters. II. Zooplankton production". Bol. Inst. Esp. Oceanog.: 6 part 1 no. 290.

   Real, F.; de Armas, J. C. and Braun, J. G. "Spatial distribution of chlorophyll and particulate organic carbon in coastal superficial waters off Canary Islands". Bol. Inst. Esp. Oceanog.: 6 part 1 no. 292.

   Marino, J. and Campos, M. J. "Tide currents affecting phytoplankton communities in Ria de Arosa". Bol. Inst. Esp. Oceanog.: 6 part 2 no. 298.

   de Armas, J. D. "Composition and distribution of suspended organic matter in Canary Islands". Bol. Inst. Esp. Oceanog.: 6 part 4.

   Corral, J.; Masso, C. and Alvarez, M. T. "A first comparative study on dry biomass, organic matter, carbon, nitrogen, C/N relation and energy content of zooplankton in Ria de Arosa and Ria de Muros". Bol. Inst. Esp. Oceanog.: 6 part 4.

   Alvarez, A.; Masso, C., et al. "A study on continental and marine water quality in Ebro Delta (Mediterranean Sea)". Scientific report of the Cooperative Project Hispano-American No. 79028.

Sweden
(L. Thorell)

1. ENVIRONMENTAL CONSEQUENCES OF MUNICIPAL WASTE WATER, SLUDGE, AND SOLID WASTE. Feeding competition between marine micro- and macroalgae. The project intends to survey the competition between macro-algae and free-living as well as fixed micro-algae in the Sound area in regard to the possibility of assimilating nutritive salts for growth.

2. THE MARINE COASTAL ZONE - CRITERIA FOR PLANNING. Assessment of consequences of dredging and dumping.

   Bottom- and water dynamics in the coastal zone.

   Reduced production of fish related to shallow dredging.

   The importance of different coastal types as spawning and growing places for fish and for production of fish-food organisms.

   Production capacity in some marine coastal areas.

Shallow marine bottom production capacity of fish in the Bothnian Sea.

Solid bottoms as indicators of environmental quality in the coastal zone.

Research Group for Aquatic System Analysis.

Coastal marine bottom ecology in the Baltic Sea - an integrated benthal-pelagic project.

Ecological model of the eutrophical course in coastal recipients.

3. ENVIRONMENTAL CONSEQUENCES OF INDUSTRIAL ACTIVITY

Development of methods for arsenic determination in environments of the Gulf of Bothnia.

Effects of metal-polluted sediments on soft-bottom ecosystems.

Vertebral injuries; Fish/Cellulose. Studies concerning the frequence of vertebral damage will be made on fish from habitats with various waste loads from the cellulose industry.

Chlorinated substances from chlorine bleaching; transport and spread in marine environment.

Transport, degradation and bioaccumulation of chlorinated lignin-derivatives in aquatic ecosystems.

Fish/metal project; injurious effects of different metals on fish:

Vertebral injuries
Metal analyses of fish
Sublethal physiological effects
Cadmium-absorbtion in fish-gill; its dependence on the metals form of occurrence in the water
Spawn/fry-tests
Population structure of Perca fluviatilis and Cottus quadricornis and and population dynamics of a pollution-recipient.
Effects of metal on and biological availability for fish

4. ENVIRONMENTAL EFFECTS OF ENERGY PRODUCTION AND THE USE OF ENERGY:

Long-term effects of oil in a marine ecosystem.

Radionuclide concentration in marine algae and invertebrates in the Sound and Southern Kattegat.

5. HAZARDOUS WASTE:

Organic-arsenic compounds in fish

Occurrence of polychlorinated dioxides and dibenzofuranes in the Baltic Sea and the Gulf of Bothnia.

6. PLANKTON BLOOMS:

The Kattegat-Skagerrak project; eutrophication in the Kattegat and Skagerrak.

Eutrophication in the Bay of Laholm and its surrounding waters.

Production stimulating substances in the Southern Kattegat

United Kingdom
Scotland
(A. D. McIntyre)

This report gives details of research relevant to the Marine Environmental Quality Committee and to Council resolutions, conducted at the Marine Laboratory, Aberdeen, and the Freshwater Fisheries Laboratory, Pitlochry. Appropriate resolutions are indicated in brackets.

MARINE LABORATORY

1. Sewage. Further studies were conducted on the effects of dumping sewage sludge on grounds off the east coast of Scotland. Water and sediment were studied and chemical and biological observations made, including studies of the structure of benthic animal communities (C. Res. 1979/4:14).

2. Metals

2.1 Intercalibration. During the year the Laboratory was involved in studies of lead analysis by atomic absorption techniques, which had been identified as posing a problem as a result of the ICES sixth exercise on metal intervalibration in tissue (C. Res. 1979/4:16).

2.2 Monitoring. An investigation of elevated levels of arsenic in some fish species in relation to length and fishing area was completed in 1981 and a report is in preparation.

Monitoring of mercury levels in fish and shellfish from selected areas has continued on a routine basis at 6-monthly intervals and a more selective exercise on mercury and cadmium in the Firth of Forth is part of the Scottish contribution to the JMG programme.

A survey was made of cadmium in edible crabs from coastal areas around Scotland.

3. Oil

3.1 Monitoring. Oil-related activities in the North Sea were again kept under surveillance. In April 1981 the research vessel "Clupea" visited Sullom Voe and conducted a standard hydrographic and chemical study designed to monitor environmental levels of petroleum in the area. Biological studies involving the possible uptake of tainting substances by shellfish in the vicinity of an oily water discharge were also carried out. On the same cruise hydrographic and chemical observations were made in the Moray Firth in relation to oil exploitation in that area.

3.1 Continued

In November 1981 an extensive survey was made from RV "Scotia" round a number of North Sea oil fields to investigate the distribution and effects of hydrocarbons. The routine procedure is to sample lines of eight stations running north, south, east and west from the centre of each field. Water and sediment is collected at all stations and benthos on a more restricted basis. The samples are also studied using radio-labelled substrates to determine their content of microorganisms capable of degrading hydrocarbons. Induction of enzymes specific to hydrocarbon breakdown was examined and fish were subjected to taste panel evaluation for possible taint.

3.2 Experimental Work. A series of experiments was started during 1981 to study, in underwater chambers, the fate of oil in sediments with special reference to degradation processes due to microbiological activity. Special attention is being paid to oil associated with drill cuttings (C. Res. 1976/4:13).

3.2.1 Toxicity Testing: Tests were carried out on an ad hoc basis in connection with the issue of licenses for the dumping of wastes at sea.

3.2.2 Biological Monitoring: Research under this heading is referred to above under "Sewage" and "Oil Monitoring", and includes in particular studies of the structure of benthic macrofauna communities and of the induction of specific enzymes by a contaminant.

In addition, in the field of pathobiology, observations were made on skin lesions in the common dab (Limanda limanda) from research vessel catches off north and east Scotland in May and October 1981. The size of ulcers varied from small relatively superficial lesions to large necrotic pits with surrounding inflammation and extensive hemorrhage. Such ulcers were particularly common in a catch taken 1-2 miles from an oil platform. Full details have been submitted to ICES via the Environmental Officer (C. Res. 1981/4:6).

4. Plankton Blooms. There are no records of significant toxic plankton blooms in Scotland in 1981 and no fish or invertebrate mortalities have been reported. (C. Res. 1981/5:1).

PITLOCHRY LABORATORY

Work has continued in the Firth of Clyde area to obtain information on the transport of the mothproofing agent Eulan (a substitute for dieldrin) from carpet factories via rivers, trunk sewers or sewage treatment plants to the Firth of Clyde. Both dieldrin and Eulan (or its metabolites) have been found in crude sewage, final effluents, primary sludge, samples of both freshwater and seawater, mussels, herring, euphausids and sediments. As reported last year, the concentrations of dieldrin have decreased, but the concentrations of Eulan or its metabolites are still very low and it is believed that the more

polar materials such as the components of Eulan do not adhere strongly to particulate matter, and are less likely to be taken up by filter feeders such as Mytilus. Trace concentrations of the metabolites of Eulan have been detected in mussels, however. For the same reasons, the bioconcentration factor for Eulan in herring is much lower than for the more non-polar dieldrin. (C. Res. 1978/4:14).

The source of elevated PCB levels in the Cromarty Firth, which were first revealed by the mussel survey of 1977, is still being investigated, and samples from various discharge points have been analysed in an attempt to identify the origin of the contamination. Work on the possible relationships between PCB levels in seals and the incidence of reproductive failure in individual seals is still in progress. (C. Res. 1979/4:19).

United States of America
(C. Oviatt and J. Pearce)

The following provides information from several U. S. institutions and agencies which is relevant to the MEQC and council resolutions. Questions or requests for additional information should be forwarded to J. Pearce, NMFS, Sandy Hook Laboratory, Highlands, NJ 07732, USA.

1. Marine waste disposal.

1.1 Nutrients including ammonia, nitrite plus nitrate, phosphate and silicate, metals including copper, lead and cadmium, and a variety of toxic volatile organic compounds, were greatly elevated in the Providence River compared to other areas of Narragansett Bay and Rhode Island Sound. Factors of concentration were 20x for ammonia and copper between Rhode Island Sound and the highest concentration station in the Providence River. High nutrient concentrations led to anoxic bottom water during the 1980 summer in the Providence River. The Field's Point sewage treatment plant, the Blackstone River, the Pawtuxet River, CSO's and storm drainage were identified as major sources of pollutant materials including fecal coliform bacteria. Most of the nutrients came in via the rivers; most of the copper came in via the Field's Point effluents; and most of the lead came in via CSOs during the rainstorms. Major sources of volatile organic compounds were the Field's Point sewage treatment plant and the Pawtuxet River. (University of Rhode Island).

Microcosm experiments indicated reduced nutrient and metal concentrations when sediments were isolated from pollutant sources for a year. However, toxic levels of copper may continue to flux out of the sediment reservoir; processes which control the multitude of toxic organic compound concentrations in the water column are poorly understood. A variety of research and management strategies will be needed to understand better these problems and to improve the water quality of the Providence River and upper Narragansett Bay (University of Rhode Island).

1.2 The Graduate School of Oceanography, University of Rhode Island (URI) personnel have continued studies on the fate of ocean dumped acid-iron waste. Field studies have provided information on the short-term effects of acid-iron waste disposal at a deepwater dumpsite off the coast of New Jersey. To assess the long-term effects of the acid-iron waste, an experiment was conducted at the Marine Ecosystems Research Laboratory (MERL) facility of URI.

MERL tanks (2 m diameter and 5 m deep) provide planktonic ecosystems for experimental manipulation; to simulate conditions at the deep-water dumpsite, two MERL tanks were established with a 10°C temperature differential maintained between the surface and bottom layers. Acid-iron waste was added to the surface layer of one of the tanks at a 10^5 dilution. The decay of iron from the surface layer of the tank and the penetration of iron floc through the thermocline was followed as a function of time after the waste addition. The removal of iron from the surface layer was first order with respect to iron with a half life of 35 hr. The mechanism of iron removal was gravitational settling of iron floc and not assimilation by phytoplankton and zooplankton species exposed to acid-iron waste. The results of the MERL tank experiment were consistent with field observations of an actual acid-iron waste dump.

1.3 A synthesis and evaluation of the extensive, yet largely unpublished, data on composition, distribution and community structure of macrobenthos in the New York Bight region and Hudson-Raritan estuary continued. The impetus was an interest in determining the suitability of assessments of the macrobenthic communities and the adequacy of the existing data for detecting effects of pollution and environmental change in this heavily utilized area (Virginia Institute of Marine Science).

1.4 For several years the City of Philadelphia had dumped sludges on the continental shelf off Atlantic City, New Jersey. By court order, this practice was scheduled to be stopped within a year. As part of a USEPA study of ocean dumping, the environmental impacts of sewage disposal were assessed and the recovery of the macrobenthos after the termination of sludge dumping was monitored (Virginia Institute of Marine Science). The comparative biogeography of numerous macrofaunal groups was investigated by intensive seasonal sampling on the continental shelf off North Carolina from Oregon Inlet to Cape Lookout. Of particular interest was a sharp thermal front between the Virginian Sea and Gulf Stream waters. This front was found to move unpredictably and rapidly across large areas of the shelf, exposing the benthos (bottom dwellers) to rapid thermal change (Virginia Institute of Marine Science).

1.5 The National Marine Fisheries Service (NMFS) Ocean Pulse and NOAA Northeast Monitoring Programs continue to monitor the fate and effects of ocean dumped materials. Details are reported elsewhere in this document.

2. Deep Ocean Mining Environmental Study (DOMES).

The objective of DOMES is to identify potential environmental impact problems to be expected from commercial-scale mining of deep ocean manganese nodules. Baseline studies on existing environmental conditions (Phase I) were completed before studies concerned with prototype mining tests (Phase II) were undertaken. Some findings were reported to ICES in 1980.

The mining systems involved in commercial recovery of manganese nodules will recover nodules by means of a collector that will either be towed or self-propelled and will draw them through a pipe to the surface; at the same time, bottom sediment will also be drawn into the collector. Most of this unwanted sediment will be rejected at, or just above, the collector; some entrained sediment, together with nodules and bottom water, will be hydraulically drawn to the mining vessel. The nodules will be separated on the mining vessel, and the residual mixture of bottom water, sediments, nodule fragments, and benthic biota will be discharged at the surface. The assessment of potential impacts resulting from commercial mining operations depends upon the identification and characterization of materials included in this discharge.

The preliminary estimates of the mining discharge characteristics were made from information provided by the mining consortia prior to mining tests. Two pilot-scale mining tests conducted in 1978 provided the first opportunity to observe mining operations and allowed comparisons of earlier estimates of mining perturbations with actual results. During these tests discharge volume, particulate concentration, and temperature were measured on each mining vessel. Studies to delineate the surface and benthic plumes and to assess biological impacts were conducted during these tests from the NOAA Ship Oceanographer.

Dissolved components of discharge: Three dissolved components of the overboard discharge, nutrient ions, gases, and metals, were investigated. First, the dilution level at which the dissolved components can be detected in a plume was determined. The potential environmental effect of each component was considered and the possibility of detecting the effect was determined.

The presence of discharge nutrient ions in the mixed layer could not be measured beyond a dilution factor of approximately 3.3×10^{-4}. An increase in the primary productivity in the immediate vicinity of the mining ship equivalent to the productivity of 2.7 km^2 of ambient water could be attributable to the nitrate ions in the yearly discharge of a single commercial-scale mining ship. At no age of the discharge plume could this increase be measured.

Supersaturation of air gasses in the discharge of the air-lift system would be expected but would be measurable only to dilution factors of approximately 1×10^{-2}. Dilutions of this magnitude occur within minutes after discharge. Consequently, no threat of gas-bubble disease from the supersaturation of gases is expected.

The concentrations of several metals in the two source waters of the discharge (interstitial and bottom water) are different, but neither would be detected in the surface mixed layer farther than a kilometer from a mining ship. However, no samples for dissolved metals were taken

during the monitoring program and, since the experimental evidence for metal release from discharge solids is inconclusive, it is impossible to predict disperson patterns for dissolved metals from the discharge solids. The discharge at relatively high concentrations did not affect the rate of primary productivity or the uptake of limiting nutrient ions by phytoplankton. However, the possibility of the biomagnification of metals cannot be ruled out until unequivocal data on the release of metals from the discharge solids is in hand.

Increased oxygen demand and microbial biomass: Detection of the sediment POC and maximized oxygen demand from the initial organic matter adsorbed to the sediment particles would be limited to the upper 50 m of the water column within 15 km of the mining ship. The sediment of the benthic plume would settle to the bottom without providing additional oxidizable carbon to bacteria or higher organisms because the organic carbon on the sediment is essentially refractory. The macerated and smothered bottom fauna would be consumed by other organisms, but the amount of oxygen utilized would be undetectable and trivial comparable to the vast oxygen pool of the bottom water.

Sediment particles have been shown to stimulate bacterial growth, and this process may have contributed to elevated ATP concentrations. However, the short time that discharge solids remain in a water parcel precludes a significant alteration of the oxygen concentration in the mixed layer or thermocline.

Effect of deep-sea mining on marine phytoplankton and primary productivity: The potential effects of the deep-sea mining of manganese nodules on the local phytoplankton photosynthesis and primary production were investigated during the autumn of 1978 in the tropical eastern North Pacific Ocean. Experiments were conducted to study the short-term influence of the mining discharge on marine photosynthesis in terms of light reduction by the discharge particulates and of chemical inhibition by the release of heavy metals from the bottom sediemnt.

From the experimental results, it is predicted that a significant, short-term reduction in primary production will occur in the plume of mining discharge. Effects due to nutrient-enrichment of heavy metal toxicity are projected to be negligible. Long-term and large-scale changes in phytoplankton species composition or primary production due to the mining operations are not anticipated.

Impact of a pilot-scale manganese nodule mining test on the benthic community: The purpose of this project was to assess the impact on the benthos of a pilot-scale manganese nodule mining operation near DOMES site A in the central Pacific Ocean. Assessment was ineffectual due to the interaction of natural spatial variability; thus the power of the statistical tests that could be used to detect mining-associated changes in benthic populations was severely limited. Instead of the planned

local comparisons of pre-mining and post-mining samples, only broad regional estimates could be made with statistical validity. The limited duration and spatial extent of mining was not anticipated to affect the entire (10^3 km^2) region of the study, and no significant before-after differences were found on this unrealistically large scale. Power curves (beta error) show that macrofaunal population changes in excess of 50% over the entire region would have been necessary to assure ($P > 0.95$) detection of a before-after difference. Hence, there is no assurance from this sampling program that a substantial mining effect did not indeed occur. (University of Washington, Seattle).

3. Effects studies.

In studying a population from a relatively clean area (eastern Long Island), it was noted that some females produced eggs that were very susceptible to teratological effects, while other females produced eggs that were more tolerant. Tolerance of embryos was found to be correlated with certain characteristics of the female and of the eggs. In studying fish from Pile's Creek, a tributary of the Arthur Kill, an area heavily affected by metal and oil pollution, the vast majority of females produced eggs that were tolerant to meHg. This is interpreted as evidence for the development of resistance on the part of a stressed populaton. Uptake data indicated that tolerant eggs took up less mercury than resistant eggs. (New Jersey Marine Sciences Consortium).

The New Jersey Marine Sciences Consortium assessed M. edulis tissue accumulation and retention of mercury, cadmium, lead, PCBs, DDT, and total petroleum hydrocarbons. The metals data were presented at 1981 ICES meeting (CM 1981/E:18) but organic data are not published yet. After one year of incubation of caged mussels in New York Bight apex waters, DDT concentrations generally were below detection (.02 ppm) at all stations. The petroleum hydrocarbon bioaccumulation was similar at all stations, including a reference station outside the apex. Dramatic increase of hydrocarbons (to over 100 ppm) was observed at each station during April and May. PCB residues within mussel tissue fluctuated throughout the year. Increase in PCB concentrations (to over .6 ppm) was observed after three weeks at stations in and around the dredged material disposal site, followed by pronounced decline after ten weeks of deployment. There was gradual increase in PCB levels during spring months.

A two-year ecopathologic study of soft clams (Mya arenaria) from Newark Bay and upper New York Bay and controls from a relatively unpolluted site in Chesapeake Bay (Maryland) involved individual clams which were measured and grossly evaluated for color and lesions, after which representative portions of gill and gonadal tissues were prepared for microscopic examination. Both light and electron microscopy were used in tissue evaluation.

The New York Bay population exhibited symptoms of chronic stress at gross histologic and cytologic levels. The majority of individual clams had yellowish visceral discoloration, blackened siphons and flaccid siphonal response to tactile stimulus. Conversely, the Chespeake clams showed white, plump visceral masses, and normal muscular responses. The mean weight/mean length ratio was significantly lower for the New York Bay clams, regardless of month of capture.

Over 40% of the New York Harbor soft clams exhibited Feulgen-positive nucleii within epithelial cells associated with the food groove apparatus of the gill. Electron microscopic examination of these cells revealed that nucleii contained replicating Papilloma-type DNA virus. This represents the southernmost report of this virus to date for Mya arenaria, and the first described case within the Hudson-Raritan estuarine system. The fact that the virus is found only within ciliated epithelia of the food groove suggests a waterborne mode of infection. Feulgen-positive nucleii were observed in only 4% of the Chesapeake clams. (New Jersey Marine Science Consortium).

The NMFS Northwest Fisheries Center (Seattle) conducted research in Puget Sound (Washington) to determine the extent and nature of chemical pollution and to assess if fish and invertebrates were adversely affected. Sediment and tissue samples were collected and analyzed for organic and inorganic chemicals, including aromatic hydrocarbons (AHs), polychlorinated biphenyls (PCBs), chlorinated pesticides, other chlorinated organic compounds, and metals. Animals from which tissues were taken for chemical analyses were also examined for grossly visible and microscopic abnormalities. In addition, the community characteristics (i.e., abundance and species diversity) of the sediment-associated invertebrates and fish were defined.

Chemical analyses demonstrated that AHs, PCBs and other halogenated compounds (i.e., chlorinated butadienes and DDT) were widely distributed in Puget Sound sediment; however, concentrations varied extensively both among and within embayments. The sediments in embayments adjacent to the most populated areas, Elliott Bay (Seattle) and Commencement Bay (Tacoma), contained highest concentrations of AHs and PCBs; the levels of chlorinated butadienes were highest in Commencement Bay. Arsenic and mercury were detected only in sediment from urban areas and the concentration of lead in urban areas (ca 130,000 ppb, dry weight) was about 10 fold higher than in nonurban areas.

Worms, clams, shrimp, and crabs from urban embayments contained levels of AHs, PCBs, and other chlorinated compounds that were higher than levels in marine animals from nonurban areas. Concentrations of AHs in demersal fish tissues from all areas were generally low (less than 1,000 ppb, dry weight). This observation of low concentrations of AHs in fish in the urban estuaries was a reflection of the documented ability of flatfish to metabolize rapidly various hydrocarbons to compounds not detectable by routine analytical procedures. The concentrations

of PCBs in liver of English sole caught from urban areas (24,000 ppb wet weight) were as much as 15 times higher than those from nonurban areas. Chlorinated butadienes were found in biota from urban areas, but, with a few exceptions, were not detected in biota from the nonurban areas. Livers of sole from Commencement Bay had the highest concentrations of chlorinated butadienes detected. Muscle of English sole from both urban and nonurban areas contained low concentrations of lead and mercury (less than 200 ppb, wet weight), whereas arsenic concentrations (to 5,800 ppb, wet weight) were found in the muscle of English sole from both urban and nonurban areas.

Bottom fish in the NMFS, NW Fisheries Center studies had a variety of pathological conditions. The most commonly observed lesions were either associated with infectious agents (parasites or microorganisms) or were caused by unidentified factors (idiopathic lesions); the idiopathic lesions were found only, or were most prevalent, in fish from the urban embayments. In English sole, the fish species most widely distributed throughout Puget Sound, these urban-associated lesions included liver neoplasms and "preneoplastic" and necrotic liver lesions; liver neoplasms and "preneoplastic" lesions were most prevalent in Seattle's Duwamish waterway (8% and 12%, respectively) and in Tacoma's waterways (4% and 9%, respectively). English sole with specific necrotic lesions of the liver were most prevalent in the Duwamish waterway (18%) and along Seattle's waterfront (20%). Fish with the above-mentioned lesions had abnormal blood cell counts and concentrations of serum components; these changes were indicative of severe organ disfunction.

Statistics were used to evaluate possible relationships between the prevalence of English sole with liver lesions and the chemical composition of the sediment in areas from which the affected fish were captured. In one method, the sampling stations were arranged into eight groups on the basis of cluster group analysis. The highest prevalences of English sole with these lesions were found at stations in two cluster groups. These groups were characterized as having high concentrations of sediment-associated metals and AHs. The apparent association between the prevalence of these liver lesions and the sediment concentrations of the two classes of chemicals was supported by the results of another statistical test, the Spearman rank correlation. The prevalence of English sole with liver neoplasms and specific necrotic lesions was positively correlated ($p \leq 0.05$) with the relative sediment concentrations of AHs and metals, whereas the prevalence of this species with "preneoplastic lesions" was positively correlated only with aromatic hydrocarbons ($p \leq 0.01$).

The abundance of fish, and the number of fish species were generally higher in the estuarine bays (Commencement and Elliott Bays) compared to the inlets and open bays. For sediment-dwelling invertebrates, the average highest species richness values were found in the reference areas and the outer portions of the estuarine bays. The lowest values were in sediments from the urban waterways and inner portions of the urban associated areas.

These findings indicate that hundreds of potentially toxic chemicals are present in Puget Sound sediments from as far north as Bellingham Bay to as far south as Budd Inlet. Many of the chemicals are found in a variety of benthic and pelagic organisms and appear to pose a threat to their health. The threat to the consumer is not known at present and can only be determined through further research (Northeast Fisheries Center, NMFS).

Laboratory studies on the effects of low oxygen were conducted, in a specially designed experimental facility, to determine the capabilities of juvenile red hake and juvenile bluefish, Pomatomus saltrix, to avoid anoxic conditions. Experiments show that when exposed to sublethal levels of low oxygen, hake demonstrated avoidance capability as did the bluefish. This behavior in red hake would lead to ecological stress, i.e, increased vulnerability to predation, while in bluefish, the response would be to increase survival (NMFS, Sandy Hook Laboratory).

3.1 Physical effects

With funds from USEPA the dispersal of toxic material in Chesapeake Bay and the role of the macrofaunal community in determining the distribution of toxic substances were studied. Through their burrowing, ventilation and feeding habits, macrofaunal organisms may either resuspend material or increase its rate of burial. These mechanisms were investigated with X-ray examination of biogenic structures in sediments and by observation and experimentation with live organisms (Virginia Institute of Marine Science).

A research program on the stabilization of open water sediments using seagrasses has been initiated at our laboratory. A cooperative agreement between this laboratory and the U. S. Army Corps of Engineers Coastal Engineering Research Center is concentrating on producing a low-cost seagrass transplanting technique. Research activities required to produce this technique includes monitoring environmental parameters such as light and current velocity in regard to productivity and population dynamics of transplanted species. Current flow and wave models of seagrass meadows are being developed using a flume and a wave tank, corroborated by field measurements in similar grass beds. These models will yield information on stability and erodability of potential transplanting sites before and after the introduction of seagrasses. The synthesis of these data will provide: (1) cost-effective techniques for the transplantation of Zostera marina and Halodule wrightii; (2) guidelines for enhancing sediment stability of dredge sites and other physically modified areas; and (3) biologically productive habitats (NMFS, Beaufort Laboratory).

4. Transport and flux (see also item 5.2.1)

The transition metals Cu, Pb, Fe, Mn and Cd were examined to establish the temporal response in the water column over variously impacted marine sediments, to estimate long-term release rates from highly contaminated sediments and compare this release to present metal flux into an ecosystem. The concentration of Cu, Pb and Cd increased in the water column over contaminated marine sediments when the sediments were removed from metal and organic carbon sources and held in large (13 m^3) marine microcosms. Copper concentrations increased by a factor of 3 relative to the concentration in control microcosms containing slightly polluted and uncontaminated sediments during the summer and early fall. Mass balance calculations indicate that 40, 840 and 21 µmoles m^{-2} yr^{-1} of Cd, Cu and Pb respectively, were mobilized and exported from the microcosms containing contaminated sediments. Measurably contaminated sediments lost 22 and 120 µmoles m^{-2} yr^{-1} of Cd and Cu. The time necessary to return sediment metal concentrations to background levels in just the upper 1 cm was calculated to be 3, 44 and 320 years for Cd, Cu and Pb, respectively. Iron and Mn were not exported from the microcosms. Remobilization occurred in response to reduced organic loading factors to the sediment, which enables oxidation of organic matter and sulfides to proceed with concomitant release of metals (University of Rhode Island).

Numerical and observational studies of the Hudson-Raritan estuary included the development of a two-dimensional depth averaged finite difference model. Extensive comparison of calculated tidal currents, ranges and phases with observations throughout the estuary shows that the model has significant predictive skill and could be used to predict contaminant distribution (New Jersey Marine Science Consortium).

The objective of the Power Plant Siting Program is to develop and apply a deterministic mathematical model to delineate the spatial and temporal distribution of power plant effluent constituents. A report Phsical Hydrography and Dispersion in a Segment of the Chesapeake Bay Adjacent to the Calvert Cliffs Nuclear Power Plant by D. W. Pritchard and S. Rives is available (Chesapeake Bay Institute, Johns Hopkins University).

5. Contaminants

5.1 Metals

Investigations by Rutgers University personnel revealed an inverse relationship between the methylation process and the salinity of the aquatic environment. Simply, they found that at a given mercury pollution level, more methylmercury will be generated in freshwater than in seawater. The causes for the effect are complex. Hydrogen sulfide, arising from the microbial reduction of sulfate, a major

component of sea salts, ties up inorganic mercury and renders it unavailable for methylation. Also, salinity appears to favor microbial populations that demethylate rather than methylate mercury. Other effects of the ionic environment on the methylation and demethylation process are still under investigation. (Rutgers University)

The NMFS, Beaufort Laboratory, devoted a major portion of research to demonstrating the effects of the chemical forms of Cu, Cd, Zd and Mn on the bioavailability and toxicity of these metals to marine organisms. Both laboratory and field experiments have shown that it is not the total dissolved metal concentration in seawater that controls the effects of the metals, but rather, the free metal ion concentration, and the interactions between metals. It was established, using bioassay techniques involving marine microorganisms, bacteria and phytoplankton, that the toxic form of Cu, Cd and Zn is the free ion. Using isolates of algae from coastal and oceanic waters, it was shown that the coastal species has a higher manganese requirement that the oceanic species, and that cupric ion can affect manganese metabolism. The results indicate that combinations of low manganese and high cupric ion activities may retard phytoplankton growth in certain regions of the ocean, particularly where manganese depleted seawater is upwelled to the surface. It has also been shown that ionic ratios Zn/Cu and Zn/Cd can affect the Zn metabolism of phytoplankton. Other laboratory experiments demonstrated that the percent food:water contribution to the flux of Zn into fish (75% from food and 25% from water) was not changed significantly by different Zn ion activities in "equilibrated" systems.

Another aspect of the program is concerned with developing techniques for measuring the copper complexing capacity of natural waters at sea; it has been shown that laboratory-developed microbiological assays, using natural populations to measure copper toxicity, work well aboard ship. It was demonstrated that to get meaningful results, at environmentally relevant levels, it is necessary to use trace-metal-clean techniques.

Another facet of the Beaufort Laboratory's trace metal research is devoted to determining the biochemical and physiological mechanisms of trace metal detoxification in marine organisms; this is being done in cooperation with the Duke University Marine Laboratory/Biomedical Center. The process involved in trace metal detoxification are being studied in laboratory and environmentally-exposed shellfish, using biochemical procedures to detect the presence of metal-binding, metallothionein-like, proteins. These proteins have been demonstrated in both molluscs and crustaceans exposed to cadmium and copper in the laboratory. Results indicate that intracellular partitioning of trace metals is affected by the rate and level of accumulation of copper and cadmium in oysters. In the blue crab the route of administration of cadmium, food or water, controls the tissue distribution of the metal (i.e., cadmium accumulated from food is highest in hepatopancreas, and highest in gills when

accumulated from water). The blue crab also produces two different cadmium-binding proteins, one in the hepatopancreas and the other in the gills, and these two proteins appear to be of similar molecular weight and function, but different in structure. In addition, oysters collected in polluted environments on east and Gulf coasts have been analyzed for total trace metal concentrations and the presence of metallothionein-like proteins. These animals had concentrations of zinc that ranged from 15,000 µg/gram dry wt to 400 µg/gram and of copper that ranged from 1100 µg/gram to 35 g/gram. Metallothionein-like proteins were demonstrated for copper in all oysters examined but no specific low molecular protein was found in any oysters which bind zinc.

5.2 Petroleum

Lehigh University (Pennsylvania) investigators explored the possibility that sensitivity to napthalene might change with seasons; mysids were collected monthly and were tested at normal water temperatures (between 7 and 25°C). Only a few previous studies have investigated temperature effects on hydrocarbon toxicity in crustaceans, and none has combined such a study with an investigation of effects of season.

They uncovered a seasonal shift in sensitivity to napthalene; mysids were more sensitive during summer months (probably the period of highest oil pollution because of summer boat and auto traffic). Median lethal concentration after a four-day exposure was 0.8 ppm napthalene at 25°C and approximately 1.5 ppm at lower temperatures. Several dual-temperature experiments showed that increase in sensitivity was caused by exposure to temperatures above 20°C, regardless of season.

The lowest level of napthalene which kills Neomysis during a several day exposure is probably above typical levels found in most southern New Jersey coastal waters. A study of chronic effects (when exposure to napthalene extends to weeks and months) indicates that a range of temperatures must be tested to obtain a realistic estimate of environmental impact.

Studies of the recolonization of sediments after oil contaminantion were continued. Funded by the U. S. Bureau of Land Management, these studies examined the rate and successional sequence of macrofaunal recolonization of defaunated sediments. The studies were aimed particularly at comparison of recolonization patterns in non-contaminated sediment versus oil-contaminated sediment such as might be associated with the anticipated oil and gas development of the outer continental shelf. (Virginia Institute of Marine Science).

A field and laboratory study, done in collaboration with Battelle Pacific Northwest Laboratories, on a cancroid crab species, Cancer magister, and a major prey item, the littleneck clam, was completed.

Results showed that although the concentrations of petroleum in the sediment were well below those that would cause mortality in either species, changes in behavior of the clams resulted in disruption of normal predator-prey interactions. Both in the field and laboratory, clams in contaminated sediment were nearer the surface making them more readily accessible to the crabs. This resulted in a significant increase in predation on the clams. Using this as a model, preliminary studies were done using the blue crab, Callinectes sapidus, and hard clam, Mercenaria mercenaria. Results indicated that these clams exhibited changes in burying behavior when placed in sediment contaminated with petroleum at sublethal concentrations.

Experiments, in collaboration with Battelle scientists, are also in progress on the effects of petroleum on the sand lance, Ammodytes hexapterus, an important pretty item for commercially and recreationally important fish species in the Northwest Atlantic. Results to date have shown that this species is highly sensitive to sublethal levels of petroleum, showing abnormal activity and burrowing behavior.

Studies done in conjunction with the U. S. EPA, were completed on the effects of drilling fluid on the behavior of post-planktonic red hake, Urophycis chuss. Following the establishment of normal baseline measures of activity, feeding and other behaviors, including symbiotic relationships with sea scallops, Placopecten magellanicus, results of experiments with drilling fluid indicated that only slight disruptions in behavior occurred. Results to date show that the fish initially avoided the introduction of drilling fluid. This response is maladaptive since in doing so they are forced to leave the protection afforded by the scallops. Results are still being analyzed as to the effects of the contaminant on feeding, activity and growth. (NMFS, Sandy Hook Laboratory).

A new project (Prediction of Oil Slick Motion in Coastal Waters) is an outgrowth of the tidal current work previously carried out. The ability to predict the motion of oil spilled in nearshore coastal waters is obviously of practical importance. Briefly stated, movement of oil on water is conventionally described by three spreading modes: inertial (gravity), gravity spreading as affected by viscous forces, and surface tension. In addition, spreading is influenced by evaporation and dissolution. However, the configuration of an oil slick in a near-shore marine environment will depend more heavily on wind stress and tidal advection. In this project, we used the periodic tidal model in Hood Canal to provide high-resolution tidal current input to an independently developed oil slick prediction model. Although only hypothetical runs have been performed, the results are very encouraging. Two tentative conclusions can be drawn from the work to date: 1) clean-up strategies based on oil "trajectory" models are inadequate for most inlets and estuaries, and 2) certain modifications of presently available oil slick prediction models would be desirable; for example, more realistic representation of beach or shore deposition processes should be included. (University of Washington, Seattle).

A quantitative acoustic method of assessing zooplanktonic and sound-scattering organisms was carried out in conjuction with the NOAA investigation of the effects of the IXTOC blowout in the Gulf of Mexico. The results showed that quantitative acoustic methods were adequate to document changes in quantity and quality of target organisms that could be related to the effects of oil in the water column. Changes in organisms were closely related to strong oil odors but not to surface oil or distance from the well. (University of Washington, Seattle).

Two studies dealing with hydrocarbon contamination were completed. In one, surface sediments from the Atlantic Outer Continental Shelf between New Jersey and Virginia were analyzed for their hydrocarbon composition. Benzene fractions of sediment extracts were found to contain a variety of polynuclear aromatics that, in general, were superimposed on complex mixtures of petrolic and/or biogenic origin. Concentrations of individual polynuclear aromatics typically were at the µg/g level referred to dry weight; these polynuclear aromatics were considered to derive from pyrogenic input. All hexane fractions contained pentacyclic triterpanes and triterpenes. The (17x)-hopane and its homologues were of special interest because of this high concentration (relative to other titerpanes) as well as their possible relation to the presence of petroleum.

In the second study, the uptake of hydrocarbons by oysters and their concentrations in sediments were studied after experimental oil spills. Oysters showed a rapid response of individual tissue hydrocarbon concentrations to the spill, followed by a gradual decrease that appeared to be related to the environmental residence time of the compound. Total aromatic concentrations in unconsolidated sediment at the maximum reached >500 parts per million (ppm) in both spill areas. In oyster tissue, maximum concentrations of total benzene eluate were <5 ppm and those of individual isomers in general were <100 parts per billion (ppb). Compositional changes with time were evident in both unconsolidated sediment and oyster extracts, resulting in increasing complexity that in the end became a basic limitation to analytical efforts for quantification from gas chromatograms. Total concentrations of benzene fractions in oysters were found to remain essentially constant over a period of at least 10,000 hours, but those of individual compounds clearly decayed to ppb levels within a few hundred hours. Unconsolidated sediment extracts were found to contain chlorinated hydrocarbons in concentrations of the same order of magnitude as those of aromatic hydrocarbons. While a few chlorinate hydrocarbons were also detected in oysters, their concentration relative to aromatic hydrocarbons was low and their structure, in general, was different from those in unconsolidated sediments. Contrary to expectations, there was no obvious correlation between the pollutants in unconsolidated sediment and those in oysters. (Virginia Institute of Marine Science)

Monitoring of a local salt marsh treated with petroleum to assess oil spillage effects and recovery processes was completed. This research was funded by the American Petroleum Institute for five years. A final report was prepared, discussing the effects of petroleum spillage on microbial populations. We also participated in another petroleum-related study which was funded by the Bureau of Land Management. In the study, designed to assess in situ recolonization of oil-treated sediments on the continental shelf (previously discussed), changes in microbial populations were measured over extended time periods. Bacteriology personnel also participated in a NOAA-NMFS-NASA-funded study to determine the extent and effects of the Chesapeake Bay plume on shelf waters and associated biota.

Dissolved oxygen levels in lower York River were determined weekly in July and August 1979 and May and June 1980. Distinct vertical stratification with bottom water concentrations below 2 parts per million (ppm) was observed on most of the 1979 sampling data.

A major study of the ecological effects of oil spilled in eastern coastal plain estuaries (mentioned above) was completed in December 1979 following a study period of four years. The study site consisted of a natural estuarine marsh creek habitat off the York River, Virginia, modified by the construction of retaining walls to enclose aquatic and marsh areas in each experimental unit. Each system was closed on all sides with the exception of an opening below the level of lowest tide to allow communication with tidal flow. Five experimental units were constructed, each having a surface area of about 810 m^2 (969 yd^2) and containing 695 m^2 (831 yd^2) of marsh, 100 m^2 (120 yd^2) of open water and 15 m^2 (18 yd^2) of intertidal mud flat. The unit furthest upstream served as the control and the four downstream units received dosages of fresh and weathered crude oil. In addition, biological sampling in the open marsh and creek areas provided an estimate of the effects of enclosing the marsh. Five hundred and ten liters (135 gal) of fresh South Louisiana crude were added to each of the two downstream experimental enclosures beginning approximately three hours into flood tide and lasting for one hour. The weathered oil was similarly applied to the next two units upstream three days later. The weathered oil was not visible one week after the spill except as coatings on marsh grass blades, while fresh crude remained for over three weeks. Plankton populations recovered within a week, and fish mortalities, which were most pronounced in the weathered oil unit, ceased after ten days. Reductions in standing crops of marsh grasses were most pronounced during the year following the spills when peak biomass in the control exceeded the spill units by a factor of three. Recovery progressed further in the second year with peak biomass in the oiled units being about 70% of the control. The third year following the spill, recovery was nearly complete. Benthic populations were dominated numerically by oligochaetes. Significant reductions in populations of this dominant organism and in populations of polychaetes and amphipods were demonstrable for a period of three years, although most of the populations showed definite signs of recovery. (Virginia Institute of Marine Science).

5.2.1 Petroleum Inputs

As part of a continuing project to compile an oil pollution budget for Rhode Island's major estuary, Narragansett Bay, urban runoff samples were collected by University of Rhode Island scientists at four storm drains each serving a different land use. Three to six storm events with different rainfall amounts were monitored at each drain, and the samples analyzed for petroleum hydrocarbons using glass capillary gas chromatography. The hydrocarbon (HC) loadings for each storm in terms of mass HC/area varied systematically with total rainfall, and the loading-rainfall relationship was different for each land use. Using Rhode Island rainfall records, the loadings for each storm were calculated and then summed to predict an annual flux of hydrocarbons to receiving waters in terms of mass HC/area for each land use. The industrial and interstate highway land uses gave the highest fluxes, followed by the commercial and residential land uses, respectively. Finally, an estimate of the total hydrocarbon flux to Narragansett Bay via runoff was compiled using land use data from cities and towns in the drainage basin.

5.3 Kepone

Extensive Kepone-related studies were conducted. One of the primary ojbectives of these studies was to determine whether Kepone was causing mortalities in aquatic organisms in the James River. Although all studies have not been completed, they indicated that Kepone was not responsible for acute toxicity problems in the James River or Chesapeake Bay. Likewise, data suggest that the chronic impact of Kepone on the organisms is minor, if there is any at all. These findings were extremely significant in that they showed little or no biological damage occurring to populations in the system. Assuming these conclusions to be correct, the major economic loss was restricted to limitations on harvesting of commercial species which contained Kepone in concentrations above action levels.

A second objective was to determine the magnitude of various Kepone reservoirs in the system. We completed field work to estimate the biomass of benthos, fishes and crabs in the system and designed and initiated a study to estimate the concentrations of Kepone in the sediments. This study was important since all past estimates of Kepone in the sediment reservoir were based on a very limited series of samples, i.e, less than one sample per square mile. We recently calculated a Kepone reservoir, in James River sediments, of 28,000 kg (61,729 lbs.). Kepone residues were tabulated in depth increments of 0-3.5, 3.5-6.5, 6.5-12.5 and 12.5-18.5 inches. Previous estimates ranging between 9,600 and 19,000 kg

(21,164 to 41,888 lbs.) had been made utilizing the average levels of Kepone in core samples. The actual quantity of Kepone residing in the sediments must be known before the length of time that significant biological residues will remain can be estimated. Utilizing existing information, we estimated that Kepone would remain in the system for a considerable period of time. More recent sediment studies indicated, however, that the concentrations of Kepone in the upper layer of river bottom sediments were decreasing as new, less contaminated materials settled to the bottom. Decreasing residue levels were seen in oysters, probably reflecting filtration of less contaminated sediments. Residues in finfish may also have declined, but limited data made conclusions difficult.

Over the past several years, one of the limitations in studying Kepone problems was the lack of a method for determining Kepone concentrations in water at environmental levels in the extremely small part-per-trillion range. With this method, we were able to study the potential impact of dredging in areas of Kepone contamination. A study conducted in the Skiffes Creek area of the James River showed that the dredging did not increase the dissolved Kepone levels in the water.

During the last two years, a major effort was devoted to a study of organic pollutants in the Chesapeake Bay. The objective of this project was to establish a system to detect, identify, and quantify toxic organic compounds of significance in the water column, sediments, and mollusc tissues from the Bay.

The first year's work was devoted to technique development (chemical procedures, apparatus and software). Samples of sediment and molluscs were collected once in the first year and semi-annually thereafter. Water samples were collected twice the first year and seasonally thereafter. Sampling stations were distributed throughout the Bay.

An outline computer system performed the bulk of the data management tasks. The gas chromatographic/mass spectral data contained information on both identified components (i.e. those on the Environmental Protection Agency's (EPA) consent decree priority pollutants list) and unidentified components. The program considered both classes of compounds, allowing assessment of accumulations of recognized toxics and maintaining a capability to perceive unusual rates of increase in other compounds that could force their identification, and possible further action. Study results include a baseline depiction of the abundance and distribution of toxic organics in the water column, sediments, and molluscs of the Bay. Additionally, some previously unknown toxic organics were identified. Finally, the availability of a functioning surveillance system for these toxic compounds will assist in making future resource management decisions. (Virginia Institue of Marine Science).

5.4 Radionuclides

Fish assemblages were sampled by otter trawls between 3850 and 4021 m near an abyssal radioactive dumpsite and found similar to those sampled at comparable depths elsewhere in the western North Atlantic at temperate latitudes. The large macrourid Coryphaenoides armatus was the dominant fish species at abyssal stations, including those near the dumpsite, with C. leptolepis second in biomass and numerical dominance. The fish assemblages at the dumpsite and controls were typifed by relatively low biomass and numerical abundance, and low species diversity and richness. The average body weight of fishes at the dumpsite and other abyssal stations was relatively large (300-600 gm).

While fish assemblages at the dumpsite were similar to those from other localities at similar depths, it cannot be concluded presently that radioactive waste disposal has had no effect on fishes. It was impossible to trawl at the rocky canyon wall near the center of the dumpsite because the nets would be destroyed. Trawl sampling at the dumpsite and other deepwater dumpsites, even where the bottom substrate is suitable, must be conducted around the periphery of such sites to avoid inadvertent catches of dumped materials hazardous to vessel personnel. We recommend that future trawl studies be supplemented with submersible observations and/or photographic observations.

Nuclide analysis of speciments of C. armatus collected during the present study showed that specimens at two of three stations examined were contaminated with radioactive americium 241. Dominant fishes near the dumpsite are large and mobile and capable of migrating long distances and it is not known the duration of time that any individual fish resides in the vicinity of the dumpsite.

Large migratory fishes such as C. armatus could act to transport nuclides away from dumpsites. C. armatus lays large numbers of pelagic eggs that develop in the upper part of the thermocline. These eggs could provide a means by which radionuclides could be transported from the abyss into epipelagic ecosystems.

Studies on the nepheloid layer in the Atlantic Ocean show that a very dense layer of suspended particulate matter exists near the bottom in the vicinity of the dumpsite. This layer is maintained and is transported southwest by the western Boundary Under Current (WBUC). The axis of the WBUC lies around a depth of 3000 m off southern New England but sweeps inshore to as shoal as 1000 m off Cape Hatteras. Radionuclides adhering to suspended particulate matter at 1000 m could be introduced into near surface ecosystems easily and quickly. In our earlier work we suggested that particulate organic carbon (POC) suspended in dense nepheloid layers might provide the energetic base for benthopelagic food webs. There is evidence for the existence of such webs. If POC in the nepheloid layer were contaminated with radionuclides it may become incorporated into

benthopelagic food webs. Some of the dominant benthopelagic fishes on the middle slope make seasonal bathymetric migrations from below 1000 m to shallower depths (500-1000 m). The benthopelagic fauna in this region has intensive trophic interactions with the mesopelagic fauna, which undergoes diel vertical migrations from near the surface at night to near the bottom during the day. Thus radionuclides could be transported from dumpsites as deep as 4000 m by horizontal and vertical migration of fishes, of their gametes, by transport of sediment, or by combinations of these mechanisms.

6. Monitoring

There is increasing evidence that considerable alteration in fisheries habitats in coastal and continental shelf water between Cape Hatteras and the Canadian border has occurred in recent decades. To insure sustained optimal yields of our fishery and wise management of this ecosystem, the Northeast Fisheries Center (NMFS) is monitoring the abundance, distribution, sources, fates, and biological fates of key contaminants (heavy metals, hydrocarbons), biostimulants (phytoplankton nutrients), and critical fishery food chain/ecosystem components (phytoplankton and their productivity). Comprehensive shelf-wide historical benchmarks for the above variables in the Fishery Conservation Zone of the Northeast have been conspicuously absent, and only in the last few years have we begun to develop them through extensive and frequent field surveys and monitoring as part of the NEFC's Ocean Pulse and MARMAP programs. During this past year the Center accomplished the following: 1) we developed the first, comprehensive benchmarks describing the magnitude of phytoplankton production of organic carbon throughout the year in coastal and continental shelf water in the New York Bight, on Georges Bank and in the Gulf of Maine. We found that phytoplankton production, in coastal waters adjacent to New Jersey, is exceptionally high and that the extent of eutrophication in this area is more widespread than previously believed; 2) temporally and spatially reliable baselines were also developed describing the abundance, distribution and size-composition of phytoplankton biomass (chlorophyll a), and the shelf-wide distribution of nutrient-biostimulants (nitrate, phosphorus, silicate, ammonium) which are involved with eutrophication; 3) we developed significant comprehensive benchmarks for the distribution of trace metal contaminants (Cd, Pb, Cu, Ni, Zn, Hg, Cr) in seabed sediments (a sink for many contaminants, and in key demersal species of finfish and invertebrates; and 4) we played a key role in making standardized collections of fish and sediment samples for hydrocarbon analyses. Through contracts with analytical expertise outside the Northeast Fisheries Center, data on levels of hydrocarbon contaminants such as PCB's, PAH's, and coprostanol in animals and seabed sediments was collected. Results of these hydrocarbon surveys, reported in our annual monitoring program report, indicate a wide distribution of these contaminants in biota and shelf sediments.

6.1 Benthic monitoring

During 1981, 30 sites over the northeast continental shelf were sampled semiannually for sediment grain size, organic carbon and nitrogen, and benthic macrofauna community structure. Resulting data are being compared to information from past cruises and from available historical studies to determine spatial-temporal trends in fauna as related to contaminants. Numbers of species and amphipods are sensitive indicators of environmental stress, with higher values expected in less stressed areas. Data indicate that continuing contamination has reduced numbers of species and amphipods in the inner Bight relative to the reference site, but that (after correcting for differences in sieve sizes) there is no clear evidence of improving or deteriorating environmental quality at any of the sites over the past eight years.

We planned and led the annual summer sampling of 65 stations in the New York Bight for sediment composition, organic and inorganic contaminants in sediments and demersal fish and shellfish, and contaminant effects on benthic macrofauna. Data analyses provide a model for future monitoring effects, in that we have begun (working with the Environmental Chemistry Task) to merge several data sets (macrofauna, sediments, contaminants in sediments and biota) to achieve a more quantitative, integrated assessment of contaminant fates and effects. Several data sets suggest a slight change in the sludge beds during the past decade.

Numerous in situ observations and experiments were carried out to determine factors (e.g. pollution, predation and competition) affecting inshore surf clam populations in the New York Bight. In 1981, clam spat settled from about 15 July-15 September. Settlement densities were $\sim 250/m^2$ off northern New Jersey (equivalent to 1979 densities but an order of magnitude lower than 1980 settlement). Juveniles of predators on small clams (mostly crabs, but also moon snails) settled during the same period; these predators appear to eliminate nearly all juvenile clams in most years. Experiments with sediment trays indicated clams would settle in sediments from contaminated areas. More of this work will be done in 1982, to determine whether settlement (and growth) differ between contaminated and cleaner sediments. In both lab and field experiments, clams burrowed as quickly in sands from the sewage sludge dumpsite as from a control area.

Benthic research is examining how the composition of communities of benthic invertebrates may influence fishery resource distribution and production and how pollution and other man-induced alterations affect this role or value of the benthic community to fish. Our approach to addressing these questions includes assessing how benthic community change affects the quantity (standing stocks and secondary production), quality (nutritive value and contaminant burdens), and availability (organismal size and accessibility) of benthic organisms to fishery resources as food. (Northeast Fisheries Center, NMFS).

Seabed metabolism using the Pamatmat corer on the continental shelf from Cape Hatteras to Nova Scotia was monitored on a regular basis. The New York Bight dumpsites continued to have high rates of oxygen consumption compared with all other areas of the shelf between Cape Hatteras and Nova Scotia. Overall a general elevation in seabed respiration rates occurred between Delaware Bay and Cape Cod compared with shelf areas further to the north or south. Such elevated rates were indicative of continued higher levels of organic loading to the seabed.

During the year cooperative studies were also carried out with Brookhaven National Laboratory in regard to the Hudson-Raritan plume and the fate of the winter-spring bloom of phytoplankton. Studies were also continued comparing in situ with shipboard measurements of oxygen consumption. (Northeast Fisheries Center, NMFS).

6.2 Phytoplankton monitoring

Highest concentrations (cell counts of 1 to 3 x 10^6/l) of the dominant S. costatum were found at stations just beyond the lower New York Bay. The diatom averaged over 73,000 cells/l during this cruise. Small diatoms, including Leptocylindrus danicus, Asterionella glacialis, Chaetoceros simplex, and Rhizosolenia delicatula predominated at the nearshore stations. Ultraplankters, round to irregularly shaped green forms, were abundant at the majority of nearshore stations.

Species diversity was lower within plume waters than at more distant stations over the shelf.

A report, "Phytoplankton Community Structure in Northeastern Waters of the United States. II. November 1978", again showed higher cell concentrations and prevalence of smaller sized species of phytoplankton near shore; this type of community suggests increased eutrophication of coastal waters compared with earlier investigations. The results of such long-term monitoring efforts are extremely important in assessing changes occurring over decades.

Algal bioassay data obtained during 1981 -- totaling 2601 cell counts -- were reduced to mean daily division rates and tabulated and indicated that nitrogen was usually the nutrient most critically limiting growth of the diatom Thalassiosira pseudonana. Phosphorus and trace metals also were frequently growth limiting in combination with nitrogen, and their importance sometimes exceeded that of nitrogen. On a few occasions, a lowering of the growth rate due to scarcity of silicate and vitamin B_{12} was evident. Variation of importance of the nutrients was seen from station to station and between water layers at the same locale. These data point to a more complex chemical water quality regulating mechanism for phytoplankton in Northeast shelf waters than suggested by the classic concept of nitrogen limitation.

Olisthodiscus luteus was screened to the toxicity of 12 metals in concentration ranges based on values reported for the area. Manganese, zinc, molybdenum, lithium, mercury, and arsenic were not inhibitory. Higher concentrations of iron, copper, cadmium, chromium, lead, and nickel were partially inhibitory, but not algicidal. The results suggest that metal toxicity may at times influence abundance and dominance of this species in the Hudson/Raritan estuary. (Sandy Hook Laboratory, NMFS).

The Lamont-Doherty Geological Observatory of Columbia University has continued to study the production and fate of phytoplankton size fractions in the plume of the Hudson River, New York Bight. Seasonal effects of water column stability, phytoplankton growth, and copepod grazing on the biomass of phytoplankton size fractions are described in the context of variations in particulate organic carbon (POC). Net plankton biomass was more variable in time (between weeks and months), while nanoplankton biomass was more variable in space (between surface and bottom layers and between stations).

Biomass was highest and most uniformly distributed during February-March when net plankton diatoms dominated and doubling times approximated the flushing time of the plume. Biomass declined rapidly with depth and distance from the mouth of the estuary during June-July when nanoplankton dominated and doubling times were short relative to the flushing time of the plume. Variations in POC were well correlated with phytoplankton biomass when net plankton dominated and biomass was limited by sinking and mixing. When nanoplankton dominated, biomass was limited mainly by grazing and correlations between POC and biomass were poor. It appears that most of the biomass produced by net plankton diatoms sinks from the surface layer before the summer thermocline develops, while most of the biomass produced by nanoplankton during the summer enters pelagic food chains before sinking from the surface layer. (Lamont-Doherty, Columbia University).

A long-term monitoring program on the composition, concentrations, and distribution of phytoplankton over the eastern continental shelf of the United States was done in 1968 through 1971; it was continued uninterrupted from 1978 to the present under the Ocean Pulse Program. To date, data from over 50 cruises and 1000 stations have been processed and placed in a computer program for processing. Results include: 1) The identification and characterization of phytoplankton for the eastern continental shelf of the U. S.; 2) identification of spatial distribution, biomass and primary production over the shelf; 3) the seasonal assemblages present, and successional patterns that occur; 4) identification of dominant and ubiquitous species; and 5) relationship of entry of estuarine phytoplankters on to the shelf. Presently, long-term changes or patterns of change are being analyzed from the data base. In addition to the above, a short-term, but more intense analysis of phytoplankton composition, concentrations, and

biomass was done in regard to the Chesapeake Bay plume on to the shelf during three different seasons. A water column study of phytoplankton in relation to Nantucket Shoals and a broad area study across the shelf break southeast of Georges Bank were also accomplished. (Old Dominion University and NMFS, Sandy Hook Laboratory).

6.3 Plankton blooms

Dinoflagellate red waters or "red tides" occurred periodically in the Chesapeake Bay estuary and its tributary rivers for the past several years. Some of these red waters are transitory, persisting for only a few days in localized waters, whereas others persist for longer durations and cover more extensive reaches of the tributaries and segments of the Bay.

Extensive red waters in the York River have been composed of several species, including Gymnodinium splendens, Cochlodinium heterolobatum, Peridinium triquetrum, and Prorocentrum mariae-lebouriae. At various times, these organisms have been the dominant species of almost monospecific red water formations. During 1979, red waters of Peridinium triquetrum were present in April, a period of rapidly warming water temperatures, clear days and relatively high solar radiation. During the summer months, when overcast conditions persisted and numerous summer showers were commonplace, no significant red water formations occurred, in comparison to the summers of 1975 and 1976 when extensive red waters of Gymnodinium splendens occurred and to 1978 when a prolonged red water formation of Cochlodinium heterolobatum developed.

During the summers of 1980 and 1981, both periods of drought throughout the Chesapeake Bay drainage basin, extensive dinoflagellate red waters of Chochlodinium heterolobatum persisted for several weeks when the salinities were greater than 20 ppt and temperatures more than 26°C. In addition, a continuum of red water formations of mixed populations of dinoflagellates preceded those of C. heterolobatum. During 1981, the pound net fishery was at a minimum. The 1981 C. heterolobatum red water formation was disrupted with the occurrence of tidal mixing associated with the passage of Hurricane David offshore. (Virginia Institute of Marine Science).

6.4 Biological effects monitoring

Studies to delineate the effects of environmental impacts in the marine ecosystem continued to emphasize physiological, biochemical, genetic and bacteriological effects. Baseline monitoring of blood in a variety of marine animals continued, including measurements in winter flounder, windowpane flounder, yellowtail flounder, and sea scallop. Oxygen consumption rates of these same animals were also measured. Sea scallop adductor muscles were collected for examination of enzymes involved in carbohydrate and nitrogen metabolism. Sediments, water, and selected animals were analyzed for anaerobic bacteria, particularly the toxicogenic anaerobe Clostridium perfringens, used as an indicator of fecal pollution.

Data from our benchmark monitoring form a bank of seasonal information on the metabolism of the representative animals being studied, while bacteriological analyses provided us with data on the seasonal abundance and distribution of bacteria potentially harmful to fish or to fishery products.

Laboratory studies at the Milford (Connecticut) Laboratory continued on the effects of heavy metals on a variety of indicator or sentinel animals, including the American lobster, sea scallop, windowpane flounder, blue mussel, American oyster, bay scallop, and surf clam. Metals studied included mercury, cadmium, copper, and silver. We measured oxygen consumption rates, changes in blood composition, metal uptake, and patterns of biochemical activity in exposed animals. (NMFS, NEFC).

6.4.1 Bioassays

Laboratory studies of metal uptake by marine organisms held in exposure systems for lengths of time ranging up to 21 months have resulted in significant findings and point the way for new monitoring and research efforts. For example, mussels exposed to silver accumulated this metal at a rate related to the concentration at which they were exposed. Surprisingly, however, these mussels also accumulated significantly greater amounts of copper than did controls from the ambient seawater, increasingly so with higher concentrations of silver. We have no explanation as yet for this phenomenon, but future studies will be designed for its clarification. Learning the reason for this and other metal-induced changes will help to evaluate and assess the impact of contaminants in the marine environment, where many natural and man-made variables interact.

6.4.2 Physiology

Physiological studies have combined laboratory and field studies into a coordinated research program that interfaces with the Center's multidisciplinary program on the effects of anthropogenic contaminants on living marine resources. During the past year we participated in cruises where we conducted gill-tissue respiration measurements, preserved gill tissue for scanning electron microscopy, and collected blood samples from selected finfish, crustaceans, and molluscs. Among our accomplishments were a demonstration of the usefulness of a coordinated biological effects monitoring program by showing stress in a sea scallop population using respiratory measurements, blood values, and enzyme changes, and a demonstration of the usefulness of blood measurements as a screening technique when we were able to provide pathologists with data on fish populations with low hematocrits as an aid in selecting groups of fish for detailed blood parasite studies. We added significant amounts of data to our biological effects data

base and initiated a new biological monitoring technique -- scanning electron microscopy. In addition to the shelf-wide cruise activities, we monitored blood parameters of windowpane flounder at three stations in Long Island Sound and established a seasonal blood profile along a pollution gradient. In another pollution gradient study, we continued our very productive inter-agency study with the Environmental Protection Agency laboratory in Narragansett, Rhode Island, on effects of pollutants on blue mussels in Narragansett Bay.

In the laboratory we measured metabolic changes in lobsters over the molt cycle, an important factor when using crustaceans as physiological or biochemical monitoring animals. We also studied the role of mode of entry of a pollutant by measuring effects of silver and cadmium introduced to crustaceans via the water column and via the food source. Studies on effects of metals on bivalves continued and a series of scope-for-growth studies were conducted on scallops under different water conditions. The laboratory effort provided data on physiology, pollutants effects, and supported field interpretations with carefully controlled experimental studies.

6.4.3 Biochemistry

During this reporting year, we concentrated on monitoring the condition of sea scallops, Placopecten magellanicus, in the field, including participation in the annual scallop resource survey cruise. Additionally, scallop samples were collected for biochemistry by resource survey personnel at Woods Hole during five survey cruises. Several supportive laboratory exposure studies were also performed, in collaboration with the physiologists and chemists.

The single most important accomplishment this year was made possible by the acquisition of scallop specimens from two anomalous populations. One was nutritionally deficient and apparently non-spawning, and the other was manifestly under attack from one or more environmental sources. The first group (Deepwater station, Gulf of Maine) we found to maintain basal metabolism at the expense of laying down glycogen stores for gametogenesis; what recruitment takes place is probably the result of random spatfall, possibly from the Bay of Fundy. The few immature specimens collected from the deepwater sites were highly stressed (according to biochemical criteria), with insufficient energy available to support basal metabolism. The second group was collected from the Block Island midshelf station, which lies near the "mud patch", a large "sink" on the continental shelf with greater concentrations of heavy metals and total organic carbon than generally found on the shelf. These two populations produced clear patterns of disturbed energy metabolism, for which we have been able this year to establish low, moderate, and high

ranges for the adult scallop muscle. Criteria used are the comparative levels of energy demand, expenditure, and reserves, plus the general cellular redox state. In the kidneys of stressed scallops, biosynthetic and oxidative Krebs cycle activities were also depressed.

These newly established groups of biochemical criteria for stress were and are now being tested on scallops collected from other Ocean Pulse stations. At some of these, occasional signs of stress have been detected in scallop specimens; outer Hudson Valley, Baltimore Canyon, Chesapeake outer continental shelf, and southcentral Georges Bank. Comparison with "hot spot" information from other scientific groups (sediment data from chemistry, micronuclei counts - in sand lance larvae blood cells - from Genetics, etc.) reinforced our observations at the outer Hudson Valley and Baltimore Canyon and the Block Island midshelf.

Data from all stations, plus those from Resource Survey cruises, have been tablulated and either have been entered into the ADP system or are being prepared for such entry, as part of a data base for field conditions.

To develop a solid seasonal data base for scallop biochemistry, a program of monthly sampling was begun, collecting adult males and females from a single scallop population off the New Jersey coast. Data have been collected since March for kidney and phasic adductor muscle (using the biochemical criteria noted above), and record is being made of gonad condition. Determining the normal metabolic pattern for these tissues on a seasonal basis will enable more accurate interpretation of observations on animals collected from a variety of sites and strata throughout the Ocean Pulse monitoring area in the northwestern Atlantic.

In laboratory studies, two significant findings emerged: one was that sublethal levels of cadmium attenuated normal physiological responses for adjustment to heat stress, and the other was that kidneys of silver-exposed scallops developed an efficient mechanism for regulating copper intake. The first pollutant effect weakened the capacity of the animal to adapt and survive, and the second was a hormetic response, possibly transient.

6.4.4 Anaerobic Bacteriology

During the past year we developed a data base on the distribution of an obligate anaerobe, *Clostridium perfringens*, and facultative anaerobes of the *Vibrio* group in 1) animals, 2) sediments, and 3) waters at our monitoring stations in the western Atlantic Ocean. *C. perfringens*, a pathogen in sewage sludge, is an indicator of other fecal pathogens and serves as a tracer for sewage sludge dispersion.

We demonstrated its presence to be highest (in the range of 10^5-10^6/g of top sediment) in the New York Bight sludge disposal area. Next highest values of 10^2-10^4 per gram were detected at inshore and estuarine areas, with lesser and variable numbers offshore. C. perfringens is more often detected in samples contaminated by sewage than are the fecal coliforms; it is therefore a more sensitive indicator of contamination in the oceanic environment.

In our sampling of marine sediments and waters, we isolated several other pathogenic bacterial species (Vibrio and related groups) of importance to the fisheries; presumptively identified were V. parahaemolyticus, V. cholerae, V. vulnificus, and Aeromonas spp. Other bacterial isolates in these groups have yet to be identified.

Ongoing studies include in-depth monitoring at designated stations and transects, to relate the ecology of the bacterial groups to ocean dumping and anthropogenic activities. We will also continue to adapt methods for the rapid identification and quantification of other species of marine bacteria. (NMFS, NEFC).

6.4.5 Chemistry

The chemistry group provides support services for metal exposure studies of the Physiological Effects of Pollutant Stress Investigation. During the past year, these services have included weekly monitoring of the experimental heavy-metal diluter systems, as well as analysis of tissues from fish and shellfish exposed in these systems for metal uptake. Approximately 3,000 metal analyses were conducted in this latter capacity. In addition, analyses for metals and PCBs were performed on tissues of windowpane flounder collected from two widely separated locations in Long Island Sound, to determine whether any differences in concentrations of these pollutants could be detected in fish collected from polluted and from clean areas. Livers of these animals had no significant differences in metal or PCB contents for the two geographic areas.

6.4.6 Cytology, Cytogenetics, Embryology and Development of Fish Eggs

Using a modification of the so-called mammalian micronucleus test, the circulating erythrocytes of field-sampled fish show a background chromosome error (mutation) to have occurred in 0.1-0.3% of the erythropoietic cells. Although more than 6 species of commercial fish have been examined, this baseline comes largely from cod, windowpane flounder, and Fundulus, the fish studied in largest numbers. About 1,000 field-sampled fish have been studied in toto.

Efforts to apply the micronuclear test for chromosome mutation in the field to the presumed more sensitive early life history stages of fish, have been undertaken with sand lance larvae. As with adults, some larvae showed no micronuclei, but the higher end of the range (6.0%) exceeded the incidence found in adults of at least other fish species. Also, the overall average is higher at 0.5% than the 0.3 and <0.3% observed in the adults of several species thus far studied.

Considerable effort was expended this year improving methodology for applying the micronuclear test to both immature and mature erythrocytes of the head kidney, chief site of the hematopoiesis in teleosts, and in the essential prefixation dissociation of kidney cells immediately after sampling the fish at sea.

Comparisons were made of the micronuclear incidences as measured in the mature, but yet unreleased erythrocyte in the kidney, its immature form, and the incidences measured in the circulating blood. Using 1,000 mature and immature blood cells from the kidney of 10 different cod fish and 60 windowpane flounder, it was determined that the immature erythrocytes almost invariably have a higher micronuclear incidence. No difference was observed in incidences between circulating and mature but unreleased erythrocytes, except in rare fish. This is interpreted as meaning that micronuclei can be reliably measured in circulating erythrocytes as in mature forms still contained in kidney tissues. Circulating blood is sampled easier in the field, but kidneys have the advantage of allowing measurement of both mature and immature forms. Also, it is expected that the incidences, as measured in the kidney, would more reliably reflect recent exposures to chromosome mutating agents, whereas the circulating blood would reflect the integration of effects as occurring over a period of many prior months. The half-life of a fish erythrocyte, roughly nine months, is about twice that of animals.

Cytology and Cytogenetics of Amphipod Development:
In addition to work on fish, mitoses in early developing amphipod eggs were examined for errors in chromosome division attributable either to effects on the mitotic spindle leading to faulty chromoseome distribution or to direct breakage effects on the chromosomes. This is an adaptation of earlier studies on plankton-collected eggs of the Atlantic mackerel. Amphipod eggs are readily analyzed in this manner and their additional use confirms the first favorable impression of them for cytological study.

7. Remote Sensing and Monitoring.

The Superflux Symposium concerning joint NOAA and NASA remote sensing - oceanographic studies of the Chesapeake Bay plume was held in 21-23 January 1981 at Williamsburg, Virginia. Over 100 individuals participated and presented 36 papers. Physical, geochemical, and biological syntheses of the Chesapeake Bay mouth and plume were defined and the use of remote sensing applications advocated; major conclusions of the symposium were: 1) the outwelling plume waters of the bay generally are more enriched than shelf waters; 2) inorganic matter in the form of turbidity generally is higher in the plume as indicated by LANDSAT and Ocean Color Scanner satellite imagery as well as by shipboard measurements; 3) contaminants, particularly hydrocarbons associated with total suspended matter, are elevated in the plume (ninety percent of the hydrocarbons in the water column seem to be associated with suspended particulate material); 4) biostimulants, particularly those involved in primary production, are higher in the plume (according to one meeting participant, the plume with its enriched nutrients may be the dominant factor in sustaining primary production in the shelf waters off the bay during the summer); 5) organic material in the form of bacteria, chlorophyll, and phytoplankton is higher in the plume; 6) also elevated is biological activity as total plankton respiration and heterotrophic potential, both indicators of biological mineralization rates which are relevant to the processing of organic material (including wastes), regeneration of nutrients for primary production, and determination of dissolved oxygen concentrations within the water column, particularly below the pycnocline; 7) this enriched area is definable, based upon LANDSAT and other remote sensing imagery as well as on hydrographic survey data; and 8) from shipboard survey information, we see evidence suggestive of particulate material "raining out" of the water column to the benthos along the length of the plume.

USSR
(S. A. Patin and N. P. Morozov)

1. Biogeochemical research was conducted in 1981 in two main fields:

   1.1 The first was oriented towards studying microelement contents of Antarctic krill. For that purpose, the krill fishing areas were ecologically and geochemically surveyed. In addition to krill samples, the material collected included specimens of all major biotic and abiotic components of marine ecosystems.

   1.2 The second field of study is the distribution of transition and heavy metals in the ecosystems within coastal zones of the seas. The objective is to develop criteria for the assessment of maximum allowable outflows of sewage containing these metals into the sea. The results of studies of aquatic ecosystems that had been subjected to industrial sewage might lead one to the conclusion that not only is this impact conducive to the accumulation of metals in biotic and abiotic elements of the ecosystems, but it also causes grave changes in the biota, i.e. reduction of the number of species, lower abundance, and smaller morphometrical characteristics of individuals. It is noteworthy that this adverse effect occurs in what seems to present the most favorable conditions of an open bight which receives an outflow containing technogenic metals in concentrations not exceeding corresponding levels of maximum allowable concentrations for sea fisheries water bodies. This calls for the development of a special approach to estimating the maximum allowable flows of pollutants which have cumulative characteristics. Such an approach can, in our view, be based on identification of the range of increased level of pollutants in biotic and abiotic elements of the ecosystem, and on the analysis of the characteristics and magnitude of the effect of these toxicants on the biocenoses.

2. Studies in toxicology. Together with several sea fisheries research institutes, VNIRO has been carrying out programs in toxicology for some time. In 1981, the following subjects of reasearch had emphasis placed on them: 1) biological testing of sewage and individual pollutants which get into sea waters; 2) evaluation of the quality of coastal waters to be used for aquaculture; and 3) other applied studies in ecology and toxicology. Methods of raising the extent of expression and sensitivity in biotesting of the quality of the natural water and sewage continued to be developed.